NOTE: *After this Assessment was prepared, EPA modified its proposal for the HWC MACT replacement standards. The results presented in this Assessment do not reflect this change. Information on the costs, benefits, and other impacts of EPA's proposed HWC MACT replacement standards is available in EPA, "Addendum to the Assessment of the Costs, Benefits, and Other Impacts of the Hazardous Waste Combustion MACT Standards: Proposed Rule," March 2004.*

SOCIAL COST AND ECONOMIC IMPACT ANALYSIS — CHAPTER 5

This chapter analyzes social costs and economic impacts of the proposed hazardous waste combustion (HWC) MACT standards. While Chapter 4 is limited to the modeling of potential compliance costs to hazardous waste combustors and government administrative costs, this chapter examines the responses of the regulated community. To model market adjustments in response to the proposed HWC MACT replacement standards, we use data from the baseline specification to characterize the economics of hazardous waste combustion. This modeling allows us to estimate how increased compliance costs will affect incentives for hazardous waste combustion facilities to continue burning and the competitive balance in combustion market segments. We organize the discussion into five parts:

- **Overview of Results --** We first present a summary of results from the social cost and economic impact analyses presented in this chapter.

- **Social Cost Methodological Framework --** This section presents the economic theory used for analyzing social costs. The social costs of the rule describe the total value of resources used to comply with the standards and the total value of lost output resulting from the standards.

- **Modeling Market Dynamics --** This section introduces the approach we used to model market dynamics and calculate social costs and economic impacts.

- **Social Cost Results --** This section presents a detailed set of results from the social cost analysis, which are made up of economic welfare losses and government costs.

- **Economic Impact Measures --** Finally, we describe estimates of several economic impact measures: market exit estimates, the quantity of waste reallocated from combustion systems that stop burning, employment impacts, potential combustion price increases, and other industry impacts, including potential changes in the cost structure of the hazardous waste combustion market and in the profits for hazardous waste combustion facilities and air pollution control device (APCD) manufacturers. The economic impact measures are distinct from the social cost estimates in that they provide insights into the distributional effects of the rule, and address impacts that may not represent net costs to society.

As described in Chapter 1, we examine four options in this assessment: the Agency Preferred Approach, the Option 1 Floor, the Option 2 Floor, and the Option 3 Floor. Each of these options requires the implementation of chlorine controls, and all the results presented in this chapter assume that chlorine controls are implemented. However, we have also assessed these options without controls on chlorine emissions and include detailed cost and economic impact estimates for each option without chlorine controls in Appendix C.

OVERVIEW OF RESULTS

The four sections of this chapter present social cost and economic impact results, as well as a detailed explanation of the approach taken in both of these analyses. The list below summarizes some of the key results presented in the chapter:

Social Cost Results

- Our best estimate of the annual social costs associated with the Agency Preferred Approach is $57.6 million. Our estimates of the costs of the Agency Preferred Approach range from $57.0 to $85.5 million per year, with the high-end estimate representing the engineering costs presented in Chapter 4.

- Total annualized compliance costs under the market-adjusted scenarios (in which pricing increases, system closures, and waste consolidation are incorporated into the economic model) are between 27 and 35 percent lower than total compliance costs in the engineering cost scenario in which all facilities upgrade without any market adjustments to achieve lower cost options.

- More than 75 percent of the costs of the Agency Preferred Approach are borne by boilers and industrial furnaces.

- Commercial combustion systems experience the greatest savings between the engineering cost and market-adjusted scenarios, because these facilities receive additional revenues in market adjusted scenarios as on-site systems cease treating waste.

- Under the market-adjusted scenarios, a significant portion of boiler and on-site incinerator costs are offset by revenue gains at commercial facilities. For the principal analysis, approximately $9.1 million of on-site incinerator costs and $1.3 million of boiler and industrial furnace costs represent a transfer to commercial facilities. Under alternative assumptions for the sensitivity analysis, these figures increase to $10.8 million and $1.4 million.

- Total incremental government costs are less than one percent of total social costs across all MACT options.

<u>Economic Impact Measure Results</u>

- **Market exits.** Under the Agency Preferred Approach, the following market exits are anticipated: two commercial incinerator systems (but not entire facilities), 32 to 34 on-site incinerator systems, between 22 and 25 liquid boilers, and two coal boilers will stop burning hazardous waste entirely, rather than incur the rule's compliance costs.[1] We do not expect any cement kilns, LWAKs, or HCl production furnaces to exit the waste-burning market as a direct result of the proposed HWC MACT replacement standards.

- **Hazardous waste reallocated.** Market exit and waste consolidation activity is expected to result in between 120,900 and 133,000 tons of waste being reallocated from combustion systems that stop burning under the Agency Preferred Approach. Adequate capacity currently exists in the hazardous waste combustion industry to absorb this quantity of waste, which corresponds to approximately 3.4 to 3.7 percent of total currently combusted wastes.

- **Employment impacts.** At facilities that consolidate waste burning or stop waste burning altogether under the Agency Preferred Approach, employment

[1] Liquid boilers include process heaters.

dislocations of between 387and 417 full-time equivalent employees are expected. At the same time, employment gains of between 190 and 192 full-time equivalent employees are expected in the pollution control industry, and gains of approximately 382 to 385 full-time equivalent employees are expected at combustion facilities as they invest in new pollution control equipment.

- **Combustion price changes.** Prices may increase by 1.4 percent under the Agency Preferred Approach as combustion facilities face increased costs.

- **Other industry impacts.** We compare expenditures related to the proposed HWC MACT replacement standards to total pollution control expenditures and the cost of burning hazardous waste. Incremental expenditures associated with the Agency Preferred Approach represent less than 0.14 percent of current total pollution control expenditures in industries with on-site incinerators.[2] However, incremental expenditures associated with the Agency Preferred Approach represent more than 11.9 percent of current pollution control expenditures for cement kilns.[3,4] Compliance costs associated with the proposed HWC MACT replacement standards will increase the total costs of burning hazardous waste by approximately 14 percent for cement kilns, 47 percent for LWAKs, and 4 percent for commercial incinerators, though overall waste-burning costs still remain significantly lower for cement kilns than for commercial incinerators. Although costs will increase under the proposed HWC MACT replacement standards, we expect that profits will actually increase by roughly 7.7 percent for commercial incinerators and will remain fairly steady for cement kilns, as a result of increased waste volume received and revenues from waste associated with closing on-site incinerators and boilers.[5] LWAK profits may fall by 5.3 percent. Total profits for the pollution control industry are expected to increase.

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[2] Expenditure estimates do not include O&M savings associated with on-site incinerator systems that exit the market. We do not have estimates for boilers and industrial furnaces due to a lack of data.

[3] These expenditures do not account for energy savings or revenues associated with new waste that cement kilns might receive because of the proposed HWC MACT replacement standards.

[4] We do not present a corresponding estimate for LWAKs because we lack data on total LWAK pollution control expenditures.

[5] In the 1999 *Assessment*, we examined both short-term profitability (e.g., revenues minus operating costs) and long-term profitability because several facilities were only marginally profitable in the baseline. However, since the vast majority of these facilities have since exited the market, we have chosen not to examine short-term profitability in this assessment.

SOCIAL COST METHODOLOGICAL FRAMEWORK

Total social costs of the proposed HWC MACT replacement standards include the value of resources used to comply with the standards by the private sector, the value of government resources used to administer the regulation, and the value of output lost due to shifts of resources to less productive uses. To evaluate these shifts in resources and changes in output requires predicting changes in behavior by all affected parties in response to the regulation, including responses of directly-affected entities (combustion facilities) as well as indirectly affected private parties (e.g., hazardous waste generators who incur potential changes in combustion service availability or prices). We group these components of social costs into two basic elements:

- Economic welfare changes, which include shifts in consumer and producer surplus, and

- Government administrative costs.

Below, we discuss the market structure we assume for our social cost and economic modeling of the rule. We then present our approach to analyzing economic welfare changes and government costs associated with the rule.

Combustion Market Structure Used for Modeling

We assume a competitive market structure for modeling cost and economic impacts associated with the proposed HWC MACT replacement standards. While the hazardous waste combustion market is not purely competitive (e.g., individual firms act as price takers), given the extremely competitive nature of the industry (see Chapter 2), we believe this assumption better reflects the true nature of the market than other market structures (e.g., oligopolistic).[6]

One of the best indicators of the competitiveness of this market is the closure of several commercial combustion facilities during the past several years. In 2001 alone, three commercial incineration facilities exited the market: Saftey Kleen's incinerators in Bridgeport, New Jersey and Coffeyville, Kansas and the WRR incinerator in Eau Claire, Wisconsin. Six other commercial incinerators have also closed since 1995. In addition, as cement kilns have become established in the market for waste combustion services over the past decase, competition has intensified, as noted in a June 1996 *Environmental Business Journal* article: "[i]ncinerators continue to face competition

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[6] Note that while the Portland cement manufacturing market itself might be characterized as oligopolistic, our analysis focuses on the *hazardous waste-burning* component of the cement manufacturing operations. The olipoloistic nature of the cement industry would only be relevant to this rule if waste burning is used to cross-subsidize cement manufacture. Our understanding, based on other documents and public comments received in response to the 1999 standards, is that such cross-subsidization is not a significant practice in the industry. As such, the assumption that waste burning is a separate profit center subject to independent decision making is appropriate.

from cement kilns that burn hazardous waste derived fuel."[7] Given the competitive nature of the waste management market, particularly for wastes that can be burned by both kilns and incinerators, we have adopted the competitive market structure for our modeling. We believe that this approach provides the most supportable framework for assessment of the impacts of the rule.

To determine the market structure for the industry, we also assessed whether barriers to entry (due to logistical and regulatory challenges faced by waste management facilities) would tend to make this industry less competitive. While capital costs are fairly high, barriers to entry do not appear to be a significant factor, as demonstrated by the number of players that entered the market in the 1980s when waste incineration prices were high. Even in the current market, a small number of private on-site incinerators are in the process of coming on line. In addition, industries considering entry into, or expanding their presence in the hazardous waste burning market are well financed and highly sophisticated in their understanding of regulatory issues. As a result, we do not view barriers to entry as playing a major role in reducing the competitiveness of the industry.

Our economic model divides the hazardous waste combustion market into two regions: one comprised of states in the Gulf of Mexico region and one made up of all other states.[8] In the model, on-site incinerators, boilers, and industrial furnaces that must decide between compliance with the proposed HWC MACT replacement standards and off-site disposal compare upgrade costs with off-site disposal costs within the region. If these facilities choose to send waste off site, the waste goes to the nearest commercial facility in each region, subject to capacity and waste compatibility constraints.[9]

Our analysis of the hazardous waste combustion market also reflects the interdependence among markets for different forms of waste. Our economic model assumes that waste generators typically choose between treating all of their waste on site or sending their waste to an off-site facility. For each generator, this choice depends on both the composition of its waste and the price of disposal, which varies significantly across different waste forms. Therefore, a facility that generates several tons of waste that is inexpensive to dispose of may choose to treat all of its waste on site if it also generates a small amount of highly contaminated waste that is expensive to send off site.

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[7] "Hazardous Waste: A Segment Under Pressure." *Environmental Business Journal*. June 1996, 4, as cited in U.S. EPA. *Assessment of the Potential Costs, Benefits, and Other Impacts of the Hazardous Waste Combustion MACT Standards: Final Rule*, Office of Solid Waste, July 1999.

[8] These regions attempt to address the concentration of facilities and potential localized capacity constraints in the Gulf region. The 1999 *Assessment* assumed that waste generators exiting the market would send their waste to facilities no further than 200 miles away. However, information from BRS and the comments of Fred Sigg (Von Roll WTI, December 2002) suggest that long-distance transport of waste is common.

[9] To reflect the typical waste stream characteristics at different facilities, we assume that on-site incinerators will send waste to commercial incinerators and that boilers and industrial furnaces will send their waste to a commercial kiln.

Economic Welfare Changes

This *Assessment* uses a simplified partial equilibrium analysis to estimate social costs. In the analysis, changes in economic welfare are measured by summing the changes in consumer and producer surplus.[10] To measure the magnitude of these welfare changes, economists typically use econometric techniques that rely on historical price and output information to estimate supply and demand functions. However, because hazardous waste combustion markets have changed rapidly over the last several years, historical data do not accurately reflect current market conditions. In addition, the hazardous waste combustion market is somewhat segmented, with different sectors providing different types of combustion services. Therefore, available data are not adequate to support econometric analysis at this level of complexity.

As an alternative to an econometric model, we have developed a simplified approach designed to bracket the welfare loss attributable to the proposed HWC MACT replacement standards. This approach bounds potential economic welfare losses associated with the rule by considering two scenarios: an upper bound static scenario based on engineering cost estimates, and a dynamic market-adjusted scenario that incorporates changes in producer and consumer waste management practices and pricing.

Engineering Cost Scenario (upper bound)

In this scenario, we calculate an upper bound estimate of economic welfare losses by assuming that all combustion facilities (commercial and on-site) continue to operate at current output levels and prices and that all facilities comply with the proposed HWC MACT replacement standards by implementing engineering or process upgrades as outlined in Chapter 4. This estimate represents an upper bound on costs because the scenario does not allow facilities to select lower cost waste management options such as offsite disposal, consolidation, or the implementation of price changes.

Market-adjusted Scenario

In this scenario, we provide an estimate of market-adjusted private costs that accounts for potential price increases, market exits, and limited intra-facility waste consolidation in response to the proposed rule. This scenario addresses the fact that regulated facilities will likely select least-

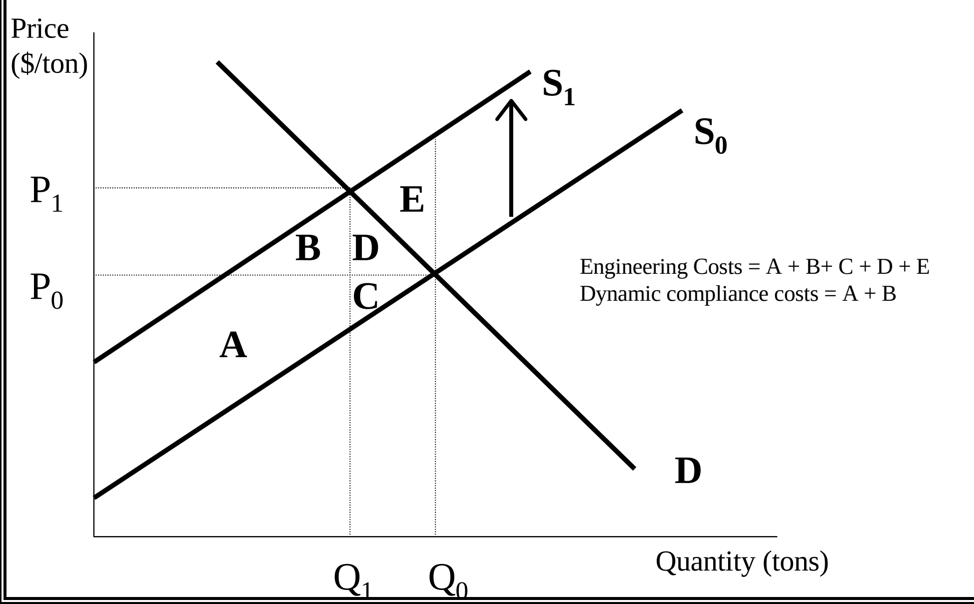
[10] In simplest terms, the producer surplus refers to the amount of income individuals receive in excess of what they would require in order to supply a given number of units of a product or service. The consumer surplus is the benefit consumers receive from consumption of a product or service in excess of what they pay for it (e.g., the difference between what a consumer is willing to pay and what a consumer has to pay for a given product or service).

cost options for waste management and compliance, and their decisions will potentially affect prices and demand for commercial hazardous waste combustion services. The scenario incorporates two different types of decisions faced by "on-site" and "commercial" facilities.

- **On-site Combustion.** In the market for on-site waste combustion (e.g., on-site treatment of waste generated on site), the market-adjusted scenario reflects the fact that compliance costs shift the market supply curve upward to S_1, as illustrated in Exhibit 5-1. As a result, some generators will select the lower cost option of exiting the on-site market and sending waste to facilities in the commercial market, bringing the on-site market to a new equilibrium of Q_1. Because of this response, compliance costs in the on-site market, represented by the sum of areas A and B in Exhibit 5-1, are less than engineering upgrade costs (A+B+C+D+E).[11]

Exhibit 5-1

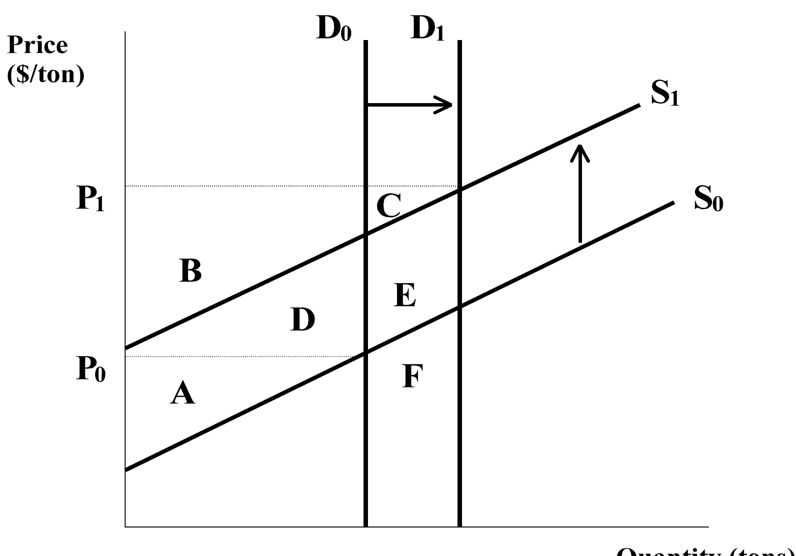
Analytical Framework for Onsite Waste Market



[11] Although Exhibit 5-1 shows that facilities exiting the on-site market do not pay upgrade costs, it does not illustrate O&M cost savings for waste generators that decide to send waste off site. Our estimate of social costs also assumes that on-site incinerators will experience these savings. Several boilers and industrial furnaces will stop treating hazardous waste, but these units are not expected to experience significant O&M savings since they will not shut down. Instead, these systems are expected to switch to alternative fuel sources.

- **Commercial Combustion.** The market-adjusted scenario accounts for shifts in both supply and demand in the commercial market. Similar to on-site combustion, the supply function for commercial combustion shifts upward as a result of compliance costs associated with the proposed HWC MACT replacement standards. However, because of systems exiting the on-site market, demand in the commercial market also increases, as illustrated by the shift from D_0 to D_1 shown in Exhibit 5-2. These shifts in supply and demand lead to changes in consumer welfare and producer surplus.[12] The change in producer surplus(B+C-A) reflects changes in waste volumes, prices, and costs at commercial incinerators. Changes in consumer welfare are split between two groups: waste generators that currently send waste off site and on-site systems that stop burning hazardous waste in response to the

Exhibit 5-2
Welfare Loss in the Commercial Combustion Market



Note:
To simplify this illustration, the demand curve is drawn vertically, reflecting a highly inelastic demand for combustion services. Our analysis of the elasticity of demand for hazardous waste combustion services is discussed more fully in Appendix F, which analyzes waste minimization alternatives as substitutes for combustion.

[12] In this illustration, we do not refer to these consumer costs as consumer surplus losses, because consumer surplus is currently zero, in the face of assumed perfectly inelastic demand (e.g., a vertical demand curve).

proposed HWC MACT replacement standards. The former face an increase in costs in the form of higher prices for commercial combustion services, as represented by areas B and D in Exhibit 5-2. Systems that exit the on-site combustion market must pay disposal costs represented by the sum of areas C, E, and F in Exhibit 5-2.[13,14] The total consumer welfare loss is represented by the sum of areas B, D, C, E, and F. The consumer losses represented by areas B and C are offset by producer surplus gains of B+C. Therefore, the total welfare loss is expressed as follows:

$$\text{Welfare Loss}_{\text{comm. market}} = A+D+E+F$$

This estimate represents the cost of commercial system upgrades plus the real resource costs of combusting waste transferred from the on-site combustion market.

<u>Government Costs</u>

The proposed HWC MACT replacement standards also result in costs to government entities which administer and enforce the new emission standards. The costs for EPA and state environmental agencies to review permit modification applications and other industry documents and to implement modifications to their programs and practices following the proposed HWC MACT replacement standards form the basis of the government cost estimates. Chapter 4 presented upper bound estimates of government costs since the analysis assumed that all combustion systems would choose to comply with the replacement standards. These results represent government costs under the engineering cost scenario. However, when markets adjust to the standards, several systems choose to send waste off site, which reduces the number of systems that governments must regulate. Under these conditions, government costs are lower than under the static scenario. Based on our estimates of market exits, we anticipate annual government costs of approximately $447,000 under the Agency Preferred Approach. A detailed description of the specific components of government costs is provided in Chapter 4, Exhibit 4-7.

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[13] Exhibit 5-2 is a simplified market depiction and does not reflect transportation costs for waste generators that decide to send waste off site. Our estimate of total social costs accounts for this additional cost.

[14] Also, since market demand in Exhibit 5-2 is portrayed as perfectly inelastic, total deadweight loss is zero. Available combustion demand data indicate that demand is highly inelastic. To the extent that demand is not *perfectly* inelastic, Exhibit 5-2 fails to capture any deadweight losses resulting from the proposed HWC MACT replacement standards. Appendix F contains additional information on demand elasticity in the hazardous waste combustion market.

<u>Social Cost Framework Summary</u>

While the hazardous waste combustion industry's dynamic, segmented nature prevents us from estimating specific demand and supply functions for different waste streams and combustion services, we are able to approximate the social costs of the proposed HWC MACT replacement standards by summing government administrative costs and total estimated private compliance costs. To provide an upper bound of social costs, we use total engineering cost estimates that assume all systems upgrade to comply with the rule regardless of cost.

HAZARDOUS WASTE COMBUSTION MARKET MODELING

To depict the two scenarios described above, we constructed a model that incorporates numerous baseline input parameters and compliance cost estimates specific to each combustion system included in the universe. The economic model calculates total compliance cost estimates necessary for the social cost analysis, as well as a variety of economic impact measures.

This section describes the economic model in more detail. We first explain how we estimate total costs under the engineering cost scenario. Next, we describe how we model market dynamics by accounting for potential price increases, waste consolidation among systems at the same facility, and system closure. We then explain how we estimate total compliance costs for the dynamic scenario. We end the section with a brief summary of both approaches.

<u>Total Compliance Costs Under Engineering Cost Scenario</u>

Our upper bound estimate of costs assumes that all facilities affected by the proposed HWC MACT replacement standards comply with the standards. We estimate total compliance costs under this scenario as follows:

1. Assign replacement MACT compliance costs to each combustion system in the universe. Some uncertainty exists about the number of facilities in the combustion universe that are actually operating. For instance, facilities may be included in the analysis that are still permitted but that have actually ceased operation, causing us to overstate the costs of the MACT standards. EPA has, however, taken several steps to verify the operating status of all systems included in the economic model at the time of this analysis.

2. Sum compliance costs across all systems for each combustion sector (e.g., cement kilns).

3. Add government costs to facility compliance costs.

The result of these calculations represents an upper bound estimate of total economic welfare losses since this scenario assumes that all facilities decide to upgrade and continue burning waste after implementation of the proposed HWC MACT replacement standards, even if lower cost options exist. The engineering cost assumptions that underlie this scenario are detailed in Chapter 4.

Modeling Market Dynamics

While the engineering cost scenario estimates total compliance costs for upgrading all existing combustion facilities, the actual social costs associated with regulation depend on the incentives and reactions of the regulated community and its customers. In this case, increased compliance costs affect both the incentives for combustion facilities to continue burning and, as a result, the competitive balance in different combustion sectors (e.g., commercial incinerators). Commercial combustion facilities may try to recover these increased costs by charging higher prices to generators and fuel blenders. To characterize post-MACT market-adjusted scenarios more accurately, we first evaluate the profitability of each combustion system in the absence of the proposed HWC MACT replacement standards (e.g., baseline profitability).[15] We then evaluate the post-MACT economic viability of systems profitable in the baseline by introducing two dynamic market elements to the economic model. First, the post-MACT scenario allows commercial combustion facilities to pass through at least a portion of their compliance costs to generators in the form of higher prices. Second, we allow combustion facilities to close individual combustion systems and to consolidate waste among multiple combustion systems at the same facility.[16] We discuss these dynamic elements below.

Combustion Price Increases

All commercial combustion facilities that remain in operation will experience increased costs under the proposed HWC MACT replacement standards.[17] To protect their profits, commercial combustion facilities will have an incentive to pass these increased costs on to their customers in the

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[15] Baseline costs include estimated compliance costs associated with the 2002 Interim Standards. As discussed in Chapter 3, we conclude that all combustion systems will continue to treat hazardous waste in the baseline. While our analysis revealed two commercial incinerator systems that are marginally unprofitable in the baseline, we assume that these two systems will remain open in the baseline because of uncertainty related to system-level waste quantity estimates and because these systems are located at a profitable combustion facility.

[16] This analysis does not consider the waste quantity reductions associated with source reduction activities and long-term process improvements. While waste management costs are a factor in these efforts, overall the rate of source reduction is not expected to be sensitive to short-term fluctuation in prices (e.g., fluctuations over a two-year period).

[17] We assume that fuel blenders will not have a separate impact on combustion pricing, although changes in hazardous waste combustion prices are likely to affect prices for blending services.

form of higher combustion prices. Price increases will be capped by the availability of substitutes for combustion (e.g., waste minimization and non-combustion treatment alternatives). Characterizing the availability of waste minimization options allows us to assess the elasticity of demand for combustion services. That is, if lower cost waste minimization options are readily available for large quantities of combusted waste, combustion facilities will be less able to pass compliance costs along to generators in the form of higher combustion prices. Price increases may also be effectively limited by competition from other combustors, including facilities in other countries that may have different cost structures.

For the 1999 *Assessment*, EPA conducted a waste minimization analysis to inform the expected change in price.[18] The analysis considers in-process recycling, out-of-process recycling, and source reduction as alternatives to hazardous waste combustion. Based on the results of this analysis, EPA estimated that as much as 240,000 tons of waste might be reallocated to waste minimization alternatives in response to higher combustion prices.[19] Since the publication of the 1999 *Assessment*, however, approximately 100,000 tons of waste have already been reallocated. In addition, given the current pricing structure of the hazardous waste combustion market, the costs of waste minimization alternatives in the short term generally exceed the cost of combustion.[20] When the additional costs of compliance with the MACT standards are taken into account, waste minimization alternatives still tend to exceed the higher combustion costs. This translates into a demand for combustion that is relatively inelastic, as indicated by the steep angle of the curve in Exhibit 5-3.[21] In addition, most combustion systems fall along the highly inelastic, rightward portion of this curve because current prices for most waste forms exceed $165 per ton.

[18] The report is included as Appendix F: Allen White and David Miller, Tellus Institute, "Economic Analysis of Waste Minimization Alternatives to Hazardous Waste Combustion," July 24, 1997.

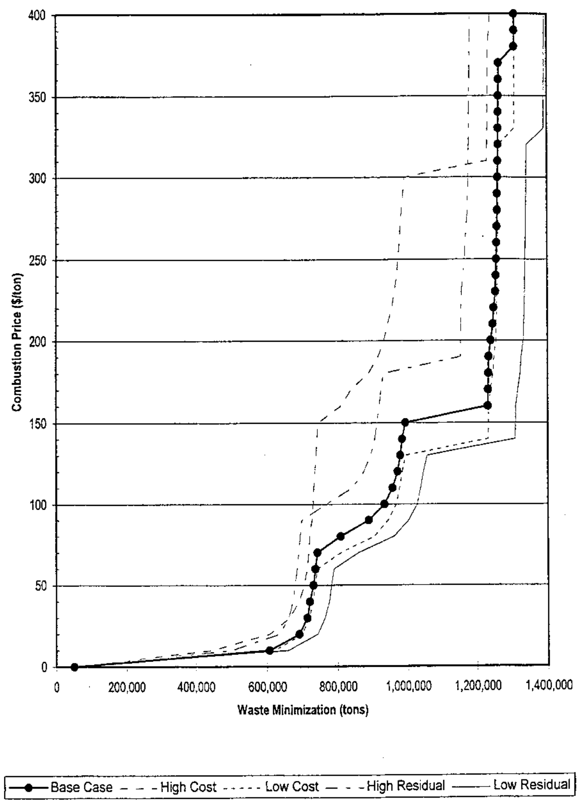
[19] U.S. Environmental Protection Agency, *Addendum to the Assessment of the Potential Costs, Benefits, and Other Impacts of the Hazardous Waste Combustion MACT Standards: Final Rule,* July 23, 1999.

[20] In the long-term, waste minimization may take place as companies upgrade manufacturing processes. However, increased waste management costs are only one factor in these larger decisions. We therefore do not anticipate that the replacement standards would cause a significant change in the quantity of waste combusted.

[21] Overall, demand is relatively inelastic. However, demand elasticity varies with (base) combustion prices: at higher combustion prices, demand is more inelastic than at lower combustion starting prices.

Exhibit 5-3

DEMAND FOR COMBUSTION ALTERNATIVES



Notes:

1. Graph excludes potential source reduction activities because the rate of source reduction is not expected to be sensitive to changes in combustion prices.
2. See Appendix F for more information on source reduction and waste minimization alternatives.

Source: White, Allen and David Miller. *Economic Analysis of Waste Minimization Alternatives to Hazardous Waste Combustion*. Tellus Institute. July 24, 1997, as cited in U.S. EPA, *Assessment of the Potential Costs, Benefits, and Other Impacts of the Hazardous Waste Combustion MACT Standards: Final Rule*, Office of Solid Waste, July 1999.

Due to the potential variance of price elasticity across different waste types and the uncertainties and limitations of the waste management alternatives analysis, we address the impacts of potential price increases on total social costs by analyzing two pricing scenarios:

1. Our principal analysis assumes a 100 percent cost pass-though (e.g., no waste management alternatives are economically available for current customers of commercial facilities, making their demand for hazardous waste incineration completely inelastic). Commercial facilities increase prices so that the additional revenues from their current customers offset total compliance costs.[22]

2. Our sensitivity analysis assumes that combustion prices do not change (e.g., a 0 percent cost pass-through in which demand for hazardous waste incineration is completely elastic and compliance costs are fully borne by the combustion facilities). Under this scenario we also assume that commercial systems charge a halogen premium that is proportional to the halogen content of the waste they receive. As detailed in Chapter 3, we therefore assume that the halogen premium for commercial kilns is approximately 11.9 percent of that charged by commercial incinerators.[23]

Waste Consolidation

In a further attempt to model industry behavior more accurately, we allow facilities with on-site incinerators to consolidate waste burning across several systems. Many hazardous waste combustion facilities have more than one permitted combustion system at the same site. Each system may burn too little waste to cover MACT compliance costs. However, the facility may be able to consolidate waste among systems, thereby reducing facility compliance expenditures.[24] As shown in Exhibit 5-4, the consolidation routine closes one system at multi-system facilities and distributes the waste from the closed system to on-site incinerators that remain open. We allow wastes to be shifted to another system at the same facility only if there is adequate capacity. In addition, within a given facility, the consolidation routine examines units from largest to smallest,

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[22] We also examined a scenario under which the increase in commercial hazardous waste combustion prices depends on the total average costs of the marginal commercial combustion system (e.g., the system with the highest average costs after implementing controls to comply with the standards). Under this scenario, commercial combustion systems' incremental revenues exceed their incremental compliance costs because even low-cost operations will increase prices to match the price of the marginal combustion system.

[23] We also analyzed a scenario where combustion prices do not change but where the price of halgenated waste treatment is the same at commercial kilns and commercial incinerators. The results of this analysis were similar to those of the sensitivity analysis presented in the main text.

[24] BRS reports waste quantities for facilities, rather than for systems. We estimate a system's waste quantity as the product of facility waste tonnage and the system-to-facility ratio of permitted waste feedrates.

consolidating waste from larger systems before consolidating waste from smaller systems.[25] The consolidation routine allows waste to be consolidated only to on-site incinerators (from other on-site incinerators or boiler systems) because these incinerators can typically burn most forms of waste. In contrast, boilers and HCl production furnaces can only burn high-Btu waste. In addition, since many boilers and industrial furnaces are physically connected to plant production systems, re-routing waste to these systems from other parts of the facility may not be a low-cost option.

Total Compliance Costs Under Market-adjusted Assumptions

We calculate total compliance costs under the market-adjusted scenario by assessing changes in profitability for each system and by estimating the different least-cost response of waste generators. This scenario accounts for potential price increases, curtailment of waste treatment at individual systems, and the consolidation of waste among systems at the same facility.

To assess commercial system profitability, we use the same approach for assessing post-replacement-MACT profitability as in the baseline (see Chapter 3), except that in the post-MACT scenario, the costs of burning are adjusted upward to account for compliance costs. In addition, post-MACT profitability for commercial systems will reflect the increased waste quantities that these systems receive as on-site systems stop burning hazardous waste in response to the proposed HWC MACT replacement standards. Changes in commercial system profitability will also reflect increases in prices for waste incineration. Thus, the basic formula is adjusted as follows:

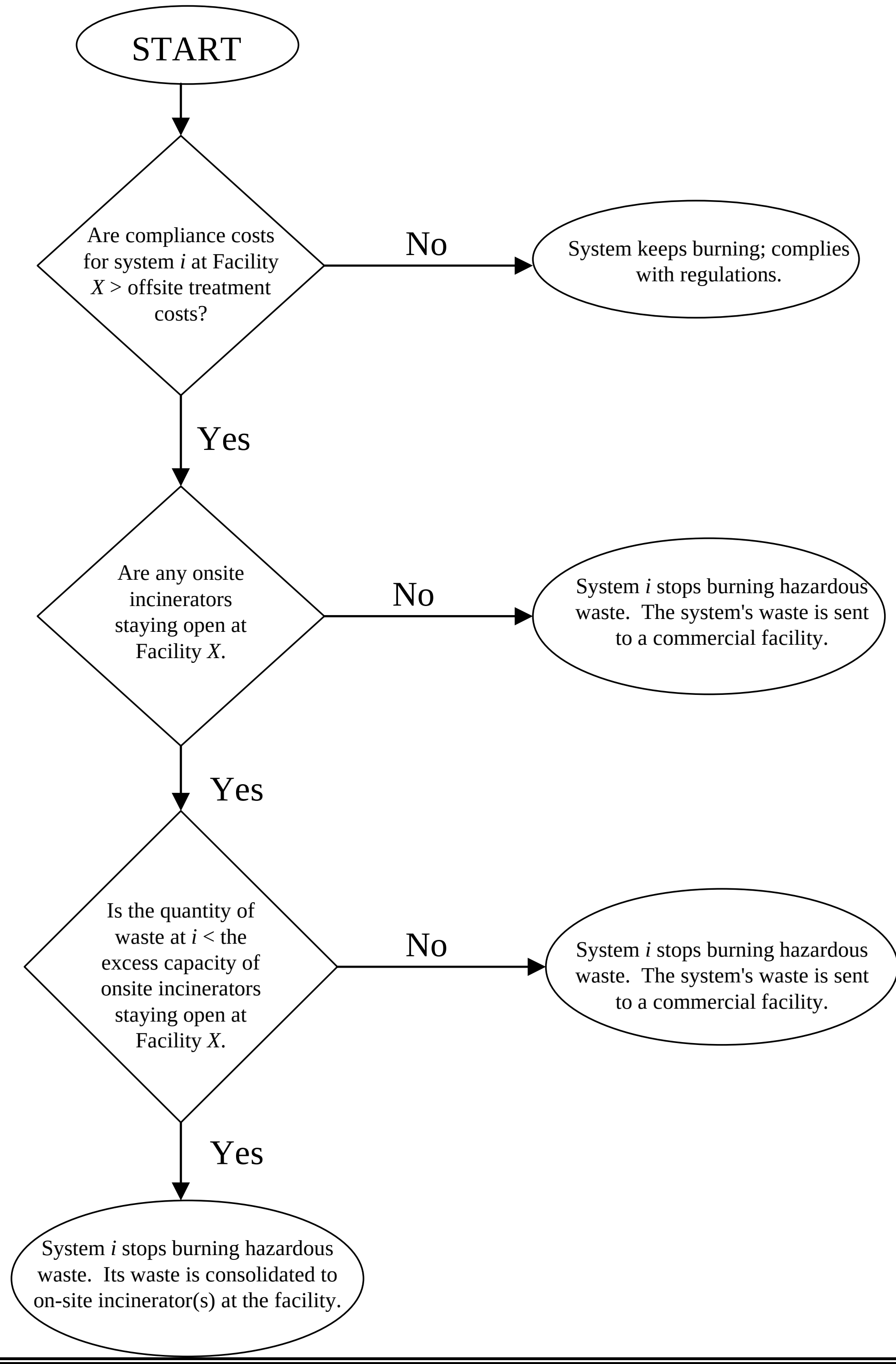
Operating Profits = Total Revenues - Total Baseline Costs[26] *- Total Compliance Costs*

[25] We assume that facilities will first consolidate those systems that are the most expensive to operate on a per ton bases. Since we lack baseline operating cost data for several on-site combustion systems, we use size as a proxy for per ton costs since larger systems can spread fixed costs over a greater waste tonnage than small systems can. For example, suppose BRS reports 100 tons of waste for a facility with two systems: one with a capacity of 150 tons and the other with a capacity of 50 tons. Since the first system makes up 75 percent of the facility's total capacity, we assume it treats 75 tons of the facility's waste.

[26] We assume baseline waste treatment costs for boilers are zero since these systems will continue to operate regardless of hazardous waste combustion regulation, and facilities with boilers will continue to require hazardous waste management.

Exhibit 5-4

Combustion System Consolidation Methodology



Where:

Total Revenues = *[Combustion market price per ton + Energy savings per ton*[27] *+ Avoided transportation costs per ton + Avoided Variable O&M Costs per ton*[28]*] * Tons burned]*

= ***P * Q***

Total Costs = *{Total fixed costs + [(Variable baseline costs per ton + Variable compliance costs per ton)* Tons burned)] + Fixed compliance costs}*

= $\boldsymbol{\{FC + [(VC + C_{VC}) * Q] + C_{FC}\}}$

As shown in the formula above, compliance costs are broken down into fixed and variable components. Although fixed costs make up the most significant portion of pollution control costs, the cost of operating pollution control technologies also depends on the amount of hazardous waste burned.

In scenarios where prices change, generators that currently send waste to commercial facilities will experience an increase in their annual disposal costs. These incremental costs for generators are transferred to commercial facilities in the form of additional revenues.

Breakeven Quantity Analysis

In the 1999 *Assessment*, EPA conducted a breakeven quantity (BEQ) analysis to evaluate profitability. Based on cost and pricing data available at the time, the BEQ analysis measured the quantity of waste that a combustion system would have to burn for prices to cover the costs of operation.[29] EPA used these BEQ estimates to assess the likelihood that combustion facilities will stop burning waste in the face of increased compliance costs.

The 1999 *Assessment* examined both short-run and long-run impacts and estimated both short-run and long-run BEQs for each facility. The short-run BEQ is the quantity at which combustion facilities generate enough revenue to cover their variable and fixed O&M costs. In contrast, the long-run BEQ is the quantity of waste combustion facilities need to cover their fixed

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[27] Energy savings apply only to cement kilns, lightweight aggregate kilns, boilers, and industrial furnaces.

[28] Avoided O&M costs apply only to on-site incinerators that choose to shut down as a result of the proposed HWC MACT replacement standards.

[29] For additional information on breakeven analyses, see Eugene Brigham and Louis Gapenski, *Financial Management Theory and Practice*, 6th Edition, 1991, The Dryden Press, Chicago, 483; or Leopold Bernstein, *Financial Statement Analysis: Theory, Application and Interpretation*, 1983, Irwin, Howewood, IL, 640-652, both of which are cited in U.S. EPA, *Assessment of the Potential Costs, Benefits, and Other Impacts of the Hazardous Waste Combustion MACT Standards: Final Rule*, Office of Solid Waste, July 1999.

capital costs, as well as their O&M costs. In both the long and short run, EPA assumed a facility would not choose to invest in new capital (e.g., pollution control equipment) unless it was confident that it could burn enough waste to cover the cost of the equipment.[30]

The main benefit of conducting the BEQ analysis in the 1999 *Assessment* was that it informed an assessment of which systems were likely to continue burning waste in the baseline and after implementation of the 1999 Standards. Because several combustion facilities were experiencing financial difficulties at the time the 1999 *Assessment* was prepared, EPA expected that several might close in response to the 1999 Standards, but the time horizon and possibility of closure for several facilities was uncertain. Some facilities expected to close in the short run might have continued burning waste for a short time if demand had increased enough for them to cover their O&M costs. Similarly, a facility predicted to close in the long run might have remained open if it had been able to attract a few more customers. By comparing actual waste quantities to BEQs, EPA identified those facilities that might have responded differently than predicted if market conditions had slightly changed.

Although useful for the 1999 *Assessment*, we have chosen not to conduct a BEQ analysis for this assessment since we assume that most of the facilities experiencing financial problems in 1999 have exited the market.[31] The vast majority of the commercial combustion systems operating today generate enough profits to offset the incremental costs of the proposed HWC MACT replacement standards. Therefore, we do not require the extra precision associated with the BEQ profitability indicator.

Summary of Modeling Approach

We employ two separate approaches for this analysis: In the engineering cost scenario, our model assumes that all combustion systems comply with the proposed HWC MACT replacement standards and the model predicts a high-end cost estimate consistent with the methodology described in Chapter 4. In contrast, the market-adjusted scenario calculates the following:

- Market exits of commercial systems due to increased costs (based on

[30] As noted in Chapter 3, some firms could decide to operate their combustion systems at a loss. We anticipate that the vast majority of combustion firms will shut loss-making operations, however.

[31] Since boilers and industrial furnaces are not covered by the 1999 Standards or by the 2002 Interim Standards, we expect that several of these systems might close in response to the proposed HWC MACT replacement standards. However, since we lack baseline hazardous waste treatment costs for boilers and industrial furnaces, we do not conduct a BEQ analysis for these systems. Moreover, because these systems are not typically commercial and also provide energy for manufacturing processes, an accurate assessment of costs specific to hazardous waste combustion would be difficult.

profitability analysis),

- Price changes for combustion services,[32]

- Market exit of on-site systems for which offsite disposal is the least-cost option,

- Intra-facility consolidation at facilities with on-site incineration,

- Additional commercial system income resulting from increased offsite disposal, and

- Employment gains and losses due to changes in waste management practices.

In the market-adjusted scenario, most systems do not incur any compliance costs if they exit the hazardous waste combustion market.[33] Total compliance costs under the market-adjusted scenario are therefore less than total compliance costs in engineering cost scenario and provide a lower estimate of welfare losses.[34]

SOCIAL COST RESULTS

As described in the methodological framework section, social costs are comprised of economic welfare losses and government costs. We bound the economic welfare loss estimates by estimating total compliance costs under the two market scenarios described above (e.g., engineering

[32] The model endogenously calculates prices in circumstances where demand for commercial combustion exceeds capacity. In this analysis, however, capacity constraints are not an issue and price changes reflect an externally determined price pass through scenario.

[33] We assume that commercial systems will incur capital costs associated with the proposed HWC MACT replacement standards. We expect that commercial systems will initially compete for additional waste as on-site incinerators and boilers stop treating waste on site. As the market for hazardous waste incineration changes in response to the proposed HWC MACT replacement standards, we do not expect that commercial facilities will be able to determine *ex ante* whether they will be able to succeed in the new market climate.

[34] We expect that compliance costs with market adjustments, assuming moderate price increases (e.g., total compliance cost recover price increase), represent a closer approximation of total economic welfare loss than the engineering cost scenario because they reflect reasonable cost-minimizing responses by affected facilities.

cost and market-adjusted scenarios). Below, we present compliance cost results for the engineering cost and market-adjusted scenarios. We then present social cost results that also incorporate estimates of government costs.

Compliance Cost Results for the Engineering Cost Scenario

Annualized compliance costs under the engineering cost scenario, in which all baseline viable combustion facilities comply with the MACT standards, range from $74.9 million under the Option 1 Floor to $121.9 million under the Option 3 Floor.[35] The upper bound estimate of annualized compliance costs under the Agency Preferred Approach, $85.5 million, is about 14 percent greater than our estimate of costs under the Option 1 Floor. Annualized costs associated with the Option 2 Floor and the Option 3 Floor are 36 percent and 43 percent higher, respectively, than costs under the Agency Preferred Approach.

As shown in Exhibit 5-5, the MACT standards will introduce aggregate cost impacts that differ greatly across combustion sectors and across regulatory options. At an aggregate level, costs for liquid boilers are higher than costs for all other combustion sources, ranging from $43.4 million under the Option 1 Floor to $67.6 million under the Option 3 Floor.[36] In contrast, annual costs for commercial incinerators, LWAKs, and HCl production furnaces do not total to more than $12 million under any of the regulatory options. However, LWAK costs increase by a factor of eight (from approximately $500,000 to more than $4 million) between the Option 1 Floor and the Agency Preferred Approach. This sharp cost increase reflects the more stringent chlorine and dioxin controls for LWAKs under the Agency Preferred Approach. Similarly, coal boiler costs nearly quadruple between the Option 1 Floor and the Agency Preferred Approach, reflecting the tighter particulate matter and chlorine controls for these sources under the Agency Preferred Approach.

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[35] As described above, the static scenario reflects our upper bound cost estimates since all systems are assumed upgrade under the static scenario.

[36] Costs for process heaters are included in liquid boiler cost estimates since the HWC MACT replacement standards regulate process heaters as liquid boilers.

Exhibit 5-5

TOTAL ANNUAL COMPLIANCE COSTS: ENGINEERING COST SCENARIO (millions)
(Excludes baseline non-viable systems, no system consolidation or market exits)

MACT Options	Cement Kilns	LWAKs	Commercial Incinerators	On-Site Incinerators	Liquid Boilers	Coal Boilers	HCl Production Furnaces	TOTAL[a]
Option 1 Floor	$8.5	$0.5	$4.0	$14.5	$43.4	$1.9	$1.5	$74.9
Agency Preferred Approach	$8.5	$4.1	$4.0	$14.5	$43.6	$6.9	$3.4	$85.5
Option 2 Floor	$28.9	$0.9	$4.9	$17.7	$59.2	$1.9	$1.8	$115.9
Option 3 Floor[b]	$27.1	$1.2	$5.1	$16.6	$67.6	$1.9	$1.8	$121.9

Notes:
a. Government costs of approximately $543,000 are included in estimates of total costs.
b. Estimates for the Option 3 Floor may be lower than estimates for the Option 2 Floor because the former is not as stringent as the latter for all systems. The Option 2 Floor standards for metals and chlorine are set based on "thermal emissions" (e.g., stack gas emissions divided the energy content of the hazardous waste feed). In contrast, the Option 3 Floor standards for metals and chlorine are based solely on stack gas emissions, regardless of waste feed. Under these conditions, a system with low overall stack gas emissions would incur relatively low costs under the Option 3 Floor. However, the same system may incur higher costs under Option 2 than under Option 3 if its waste feed has a low energy content.

Compliance Cost Results for the Market-adjusted Scenario

Total annualized compliance costs under the market-adjusted scenario, for which market exits, pricing increases, and waste consolidation are incorporated into the economic model, are between 27 and 35 percent lower than total compliance costs under the engineering cost scenario.[37]

[37] This range reflects both the 100 percent cost pass-through scenario and the zero price pass-through scenario described above.

This change in total costs results from market exits attributed to the proposed HWC MACT replacement standards. Facilities that exit the market will not incur MACT-related costs, thus reducing total compliance cost estimates.[38]

Under the market-adjusted scenario, total annual compliance costs range from $47.9- $48.5 million under the Option 1 Floor to $88.9 million for the Option 3 Floor. The lower end of the range for the Option 1 Floor reflects the sensitivity analysis outlined in the "Combustion Price Increases" section above.[39] As Exhibit 5-6 shows, if commercial facilities are able to increase prices to offset compliance costs under the proposed HWC MACT replacement standards, they will, with the exception of LWAKs, be able to make welfare gains associated with both new revenues from systems that exit the market and additional revenues from price increases to current customers. As a result, waste generators that already send their waste to commercial facilities may incur significant costs as a result of the standards. As described above, our best social cost estimate in this assessment assumes that demand for incineration is highly inelastic and, commercial facilities can pass compliance costs on to their customers through higher prices.

As Exhibit 5-6 indicates, cement kiln and LWAK costs are significantly higher in the sensitivity analysis than in the principal analysis. This disparity reflects the uncertainty associated with combustion pricing in the commercial market, which we quantified through different assumptions in the two scenarios. In the principal analysis, we assume that cement kilns and LWAKs charge the same premium for treating halogenated waste as commercial incinerators. However, in the sensitivity analysis we assume that kilns charge a lower halogen premium than commercial incinerators, which lowers our estimate of the revenues kilns will receive from boilers that stop burning hazardous waste. Exhibit 5-6 also shows that total social costs in the sensitivity analysis fall relative to the principal analysis. By assuming a lower halogen premium for commercial kilns, the sensitivity analysis effectively lowers the price of offsite disposal for several hazardous waste generators that currently treat waste on site and may decide to send waste offsite in response to the proposed HWC MACT replacement standards.[40]

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[38] As explained in footnote 31, we assume that commercial systems will incur capital costs associated with MACT compliance, regardless of whether they eventually exit the market.

[39] This scenario assumes that commercial facilities are not able to increase waste disposal prices to offset costs, and also assumes that the halogenated waste market is segmented so that cement kilns receive lower prices for halogenated wastes.

[40] We also conducted a sensitivity analysis where combustion prices increase, based on the costs of the marginal commercial system (e.g., the system with the highest costs per ton). Under this scenario, commercial facilities experience significant net savings, largely because of increased revenues from existing customers.

Summary

We develop total social cost estimates by adding government cost estimates to economic welfare loss estimates. As discussed in the "Social Cost Methodological Framework" section earlier in this chapter, our simplified approach for estimating economic welfare losses uses compliance cost estimates under two scenarios (e.g., engineering cost and market-adjusted). We take the results from these scenarios (discussed in the sections above) to develop our economic welfare loss estimates.[41]

We present estimates of total social costs in Exhibit 5-7. This exhibit presents our best estimates of social costs, reflecting a 100 percent cost pass-through consistent with the inelasticity of combustion demand. In addition, we provide the upper bound engineering cost estimates for comparison, under which all combustion systems decide to comply with the proposed HWC MACT replacement standards. Our best estimate of total social costs (including incremental government costs) under the Agency Preferred Approach is approximately $57.6 million per year. Liquid boilers and process heaters bear the most significant portion of these costs, with incremental costs of $35.5 million. In contrast, most commercial combustion facilities may actually benefit from the proposed HWC MACT replacement standards because of increased revenues from both new waste and existing customers. Net savings for commercial incinerators under the Agency Preferred Approach would be approximately $11.6 million per year, and net benefits for cement kilns would be approximately $5.1 million per year. LWAKs, however, would likely face annual costs of approximately $3.2 million. Incremental government costs are less than 1.0 percent of total social costs across all MACT options.

[41] Economic welfare losses include changes in consumer and producer surplus; we do not, however, estimate these changes independently.

Exhibit 5-6

TOTAL ANNUAL PRE-TAX COMPLIANCE COSTS: MARKET-ADJUSTED SCENARIO (millions) AFTER COMBUSTION SYSTEM CONSOLIDATIONS[a,b]

MACT Options	Cement Kilns	LWAKs	Commercial Incinerators	On-Site Incinerators	Liquid Boilers	Coal Boilers	HCl Production Furnaces	Generators that currently send waste to commercial facilities[f]	TOTAL[g,h]
Option 1 Floor[c,d,e]	$7.0 - ($2.4)	$0.5 - ($0.2)	($8.5) - ($10.8)	$10.2	$35.3	$1.5	$1.5	$0 - $12.9	$47.9 - $48.5
Agency Preferred Approach[c,d,e]	$7.0 - ($5.1)	$4.1 - $3.2	($8.5) - ($11.6)	$10.2	$35.4 - $35.5	$5.0	$3.4	$0 - $16.5	$57.0 - $57.6
Option 2 Floor[c,d,e]	$25.9 - $0	$0.9 - ($1.1)	($7.6) - ($14.9)	$12.4 - $12.5	$45.4 - $45.8	$1.5	$1.8	$0 - $34.5	$80.8 - $80.7
Option 3 Floor[c,d,e]	$25.3 - $0.7	$1.1 - ($0.7)	($7.5) - ($14.6)	$11.8	$54.5 - $54.7	$1.5	$1.8	$0 - $33.2	$88.9

Notes:

a. Because compliance costs are tax-deductible, the portion of pre-tax costs borne by the firm would be between 70 and 80 percent of the values shown above, depending on the specific firm's marginal tax bracket.

b. "Consolidation" among on-site systems allows for non-viable private combustion systems (e.g., boilers, industrial furnaces, and on-site incinerators) to consolidate waste flows with on-site incinerators at the same facility.

c. Numbers in parentheses indicate a net welfare gain.

d. Ranges reflect differences across pricing scenarios. The left number in each range represents the zero cost pass-through scenario, and the right number represents the 100 percent cost pass-through scenario.

e. Compliance costs also include costs for on-site combustion systems that decide to stop burning wastes on site. These costs include shipping, disposal, and alternative energy costs.

f. Variation in impacts for generators that already send waste to commercial facilities reflects how potential changes in hazardous waste combustion prices might affect this group.

g. Total costs include government costs.

h. Totals may not add due to rounding.

Exhibit 5-7

SUMMARY OF SOCIAL COST ESTIMATES
(millions of 2002 dollars)

		Cement Kilns	LWAKs	Commercial Incinerators	On-site Incinerators	Liquid Boilers	Coal Boilers	HCl Production Furnaces	Generators that currently send waste to commercial facilities	TOTAL[a]
Option 1 Floor	Market-adjusted Estimate	($2.4)	($0.2)	($10.8)	$10.2	$35.3	$1.5	$1.5	$12.9	$48.5
	Engineering Costs	$8.5	$0.5	$4.0	$14.5	$43.4	$1.9	$1.5	NA	$74.9
Agency Preferred Approach	Market-adjusted Estimate	($5.1)	$3.2	($11.6)	$10.2	$35.5	$5.0	$3.4	$16.5	$57.6
	Engineering Costs	$8.5	$4.1	$4.0	$14.5	$43.6	$6.9	$3.4	NA	$85.5
Option 2 Floor	Market-adjusted Estimate	$0.03	($1.1)	($14.9)	$12.5	$45.9	$1.5	$1.8	$34.5	$80.7
	Engineering Costs	$28.9	$0.9	$4.9	$17.7	$59.2	$1.9	$1.8	NA	$115.9
Option 3 Floor	Market-adjusted Estimate	$0.7	($0.7)	($14.6)	$11.8	$54.7	$1.5	$1.8	$33.2	$88.9
	Engineering Costs	$27.1	$1.2	$5.1	$16.6	$67.6	$1.9	$1.8	NA	$121.9

NOTES:
a. Government administrative costs are included in estimates of total social costs and engineering costs. Government costs for our best estimate are approximately $447,000 per year. For the upper bound estimate, under which all systems upgrade, annual government costs are approximately $543,000.

ECONOMIC IMPACT MEASURES

In addition to providing compliance cost estimates under the static and dynamic market scenarios, the economic model also calculates several economic impact measures which describe at a more detailed level how market responses change the shape of the combustion industry and affect the APCD industry. This section describes the approach and findings for each of the following economic impact measures:

- **Market exits.** When the HWC MACT replacement standards are implemented, total costs of combustion will increase, making it uneconomical for some facilities to continue burning hazardous waste. In this section, we estimate the incremental number of systems that may stop burning hazardous waste as a direct result of the MACT standards.

- **Hazardous waste reallocated.** As certain combustion systems exit the market, waste will either be consolidated to other systems at the same facility or transported to other combustion facilities.[42] In this section, we estimate the quantity of hazardous waste reallocated under the proposed HWC MACT replacement standards.

- **Employment impacts.** As specific combustion facilities find that it is no longer economically feasible for them to continue burning hazardous waste, workers at these locations may be displaced. However, the replacement standards will also result in employment gains as new purchases of pollution control equipment stimulate additional hiring in the pollution control manufacturing sector and as additional staff are required at combustion facilities for various compliance activities. In this section, we project employment changes across these sectors.

- **Combustion price changes.** Combustion prices may increase with the higher costs of waste burning. In this section, we estimate price increases under the proposed HWC MACT replacement alternatives.

- **Other industry impacts.** The MACT standards will also affect the cost structure of the combustion industry and the profits of hazardous waste combustion facilities and APCD manufacturers. In this section, we estimate the increase in profits for the APCD industry; changes in costs, revenues, and profits for different combustion sectors; and the relationship between compliance costs and current pollution control expenditures.

Market Exits

[42] Facilities may seek alternative waste management options. However, given the results of our elasticity analysis, we expect very few facilities to pursue alternative options, based on current market conditions.

Our market model uses a net cost function to identify combustion systems that will stop burning hazardous waste as a result of the proposed HWC MACT replacement standards.[43] Because the hazardous waste combustion market is a dynamic industry, we present market exit estimates incremental to those projected in the baseline.[44] Industry consolidation during the 1990s and early 2000s, however, has resulted in a more stable combustion market, and we expect no further system closures in the baseline. The analysis in Chapter 3 provides further information on our assessment of baseline viability.

For most combustion sectors, exiting the hazardous waste combustion market is fundamentally different than closing a plant. Cement kilns or LWAKs that stop burning hazardous fuels do not stop producing cement and aggregate. Similarly, on-site incinerators and boilers are generally located at large industrial facilities such as chemical plants or oil refineries. Production at these facilities is likely to continue, regardless of whether hazardous waste is treated on site or off site. Only in the case of a commercial incinerator would exit from the hazardous waste combustion market most likely signal the actual closure of the facility, and then only if all systems close.

We expect a relatively small percentage of systems to stop burning hazardous waste as a result of the proposed HWC replacement standards. Most of these particular systems are marginally viable at present and burn low quantities of hazardous waste. Depending on the assumed pricing scenario, the market model suggests the following number of combustion systems will cease burning hazardous waste under the Agency Preferred Approach:

- **Cement Kilns** -- zero out of 26 systems.
- **LWAKs** -- zero out of seven systems.
- **Commercial Incinerators** -- two of 15 systems.
- **Private On-Site Incinerators** -- between 32 and 34 of 92 systems.
- **Liquid Boilers –** between 22 and 25 of 107 systems

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[43] Net costs account for additional revenues facilities receive or cost savings they realize because of the proposed HWC MACT replacement standards.

[44] Our market exit estimates are a function of several assumptions, including the following: engineering cost data on the baseline costs of waste burning; cost estimates for pollution control devices; prices for combustion services; and data on the waste quantities that facilities burn.

- **Coal Boilers** – two of 12 systems

- **Hydrochloric Acid Production Furnaces –** zero of 17 systems

Summary

Market exits are summarized in Exhibit 5-8. As shown, the proposed HWC MACT replacement standards have the greatest impact on on-site incinerators and industrial boilers and process heaters. Market exits are not significant for any of the commercial sectors. Our model predicts that two commercial incinerator systems may exit the market. However, these systems are located at a profitable facility with multiple systems. It is possible that all systems will continue to operate if the distribution of waste among these systems differs from our assumption that waste quantities are distributed proportionate to system capacity.

Hazardous Waste Reallocated

Combustion systems that can no longer cover their costs will stop burning hazardous waste. As such, waste from these systems will be reallocated to one of the following alternatives:

- Other viable combustion systems at the same facility if there is sufficient capacity,

- Other combustion facilities that continue burning, or[45]

- Waste management alternatives (e.g., solvent reclamation).

Because combustion is likely to remain the lowest cost option, we expect that most reallocated waste will continue to be managed at combustion facilities.[46]

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[45] Some waste generators may choose to send their waste to treatment facilities in other countries. However, our economic model assumes that generators will send their waste to domestic disposal facilities. To the extent that generators send waste abroad, our analysis may underestimate costs because the disposal costs for these facilities are not a transfer to commercial facilities within the United States.

[46] In preparation for the 1999 *Assessment*, we addressed one concern that conditionally exempt small quantity generators (CESQGs) may discontinue sending their hazardous waste to kilns for use as fuel post-MACT due to the anticipated price increases and due to the anticipated exits of kilns from the hazardous waste-burning market. Given the small number of expected kiln market exits, and the relatively inelastic demand for combustion services, we believe that CESQGs will continue to send their wastes to combustion facilities.

Exhibit 5-8

SUMMARY OF MARKET EXIT IMPACTS[a]

	System-level Market Exits by Combustion Sector[b]						
	Cement Kilns	**LWAKs**	**Commercial Incinerators**	**On-site Incinerators**	**Liquid Boilers**	**Coal Boilers**	**HCl Production Furnaces**
Baseline	**0 (0%)[c,d]**	**0 (0%)**	**0[e] (0%)**	**0 (0%)**	**0 (0%)**	**0 (0%)**	**0 (0%)**
Option 1 Floor	0 (0%)	0 (0%)	2 (13%)	32 - 34 (35% - 37%)	22 - 25 (20% - 23%)	2 (17%)	0 (0%)
Agency Preferred Approach	0 (0%)	0 (0%)	2 (13%)	32 - 34 (35% - 37%)	22 - 25 (20% - 23%)	2 (17%)	0 (0%)
Option 2 Floor	0 (0%)	0 (0%)	2 (13%)	33 - 34 (36% - 37%)	29 - 30 (27% - 28%)	2 (17%)	0 (0%)
Option 3 Floor[f]	0 (0%)	0 (0%)	2 (13%)	33 - 34 (36% - 37%)	27 - 28 (25% - 26%)	2 (17%)	0 (0%)

Notes:

a. For the proposed replacement MACT options, market exit estimates are incremental relative to the baseline and include only those facilities likely to stop burning as a direct result of the proposed HWC MACT replacement standards.

b. Ranges reflect differences across pricing scenarios. The lower end of each range reflects the 100 percent cost pass-through scenario, and the high end of each range reflects results of the sensitivity analysis.

c. Numbers in parentheses indicate the percentage of systems in a given sector that will exit the market.

d. One commercial kiln may be unprofitable in the baseline, depending on kiln pricing. However, since the hazardous waste burning operations of the facility where this system is located are profitable under our most conservative pricing assumptions, we assume that the system will remain open in the baseline.

e. Two commercial incinerator systems appear unprofitable in the baseline. However, since the hazardous waste burning operations of the facility where these systems are located are profitable in the baseline, we assume that they will remain open.

f. Exits under the Option 3 Floor are less than under the Option 2 Floor because Option 3 is not as stringent as Option 2 for all systems. The Option 2 Floor standards for metals and chlorine are set based on "thermal emissions" (e.g., stack gas emissions divided the energy content of the hazardous waste feed). In contrast, the Option 3 Floor standards for metals and chlorine are based solely on stack gas emissions, regardless of waste feed. Under these conditions, a system with low overall stack gas emissions would incur relatively low costs under the Option 3 Floor. However, the same system may incur higher costs under Option 2 than under Option 3 if its waste feed has a low energy content.

In the combustion market model, waste from non-viable systems is either transported to off-site commercial facilities or consolidated to viable systems at the same facility. A system can consolidate waste on site only if an on-site incinerator at the same facility has sufficient capacity available to accommodate the extra waste. Exhibit 5-9 summarizes our approach for estimating quantities of reallocated wastes.

As a result of the predicted market exits, we estimate that between 120,900 and 133,000 tons of currently burned hazardous waste will be reallocated to other waste management systems under the Agency Preferred Approach. This corresponds to between approximately 3.4 and 3.7 percent of the total waste combusted in 1999. Exhibit 5-10 summarizes reallocated waste quantity estimates across replacement MACT options and combustion sectors. Currently there is sufficient capacity in each of the combustion market regions to accommodate all reallocated waste.

Exhibit 5-9

Routine for Calculating the Quantity of Waste Diverted to The Commercial Sector

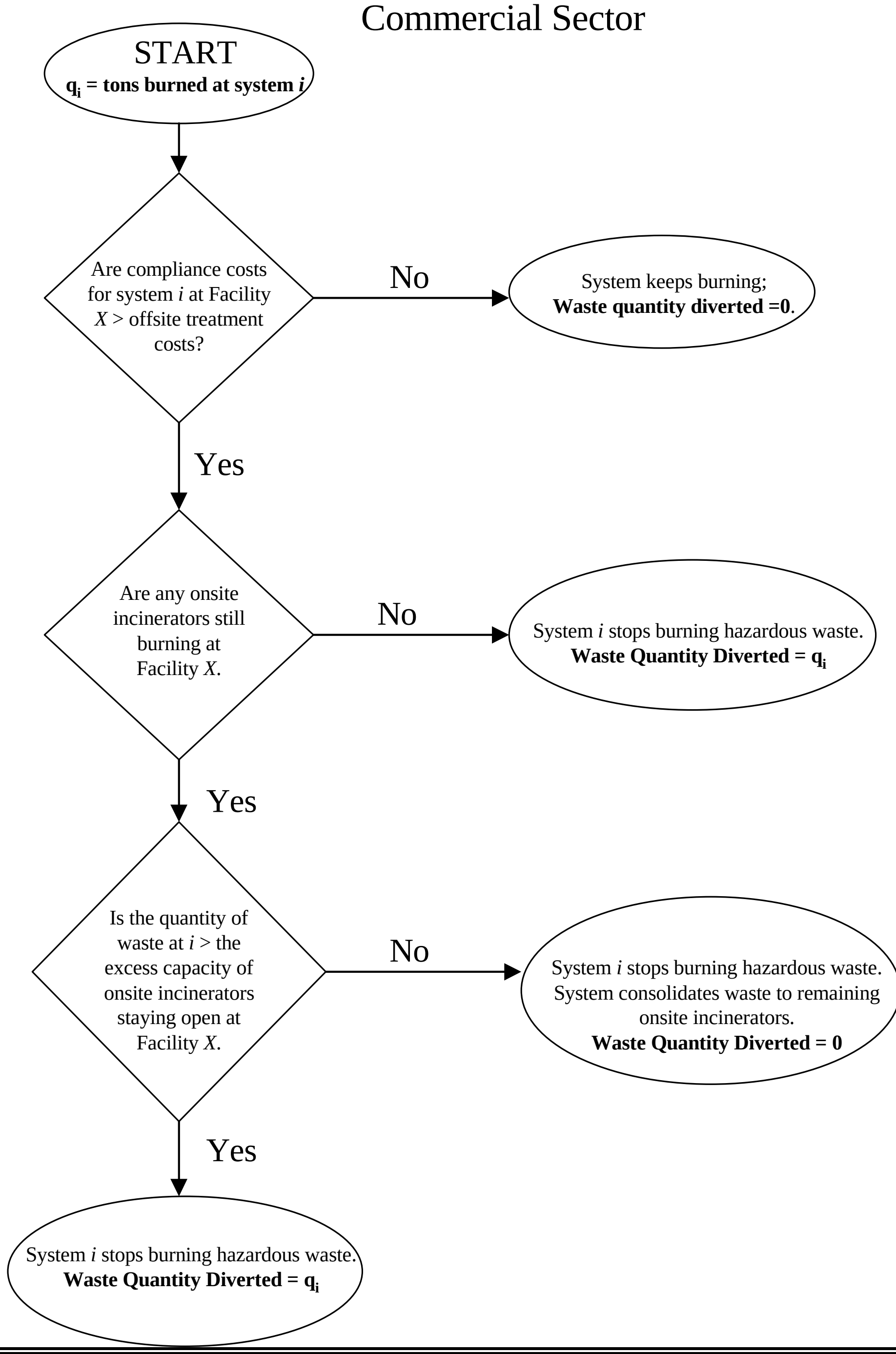

Exhibit 5-10

SUMMARY OF QUANTITY OF HAZARDOUS WASTE REALLOCATED (tons)[a, b]

	Cement Kilns	LWAKs	Commercial Incinerators	On-site Incinerators	Liquid Boilers	Coal Boilers	HAPFs	Waste Consolidated	TOTAL[c,d]
Option 1 Floor[e]	0	0	17,500	64,400 - 75,600	8,900 - 9,800	30,100	0	67,300	120,900 - 133,000
Agency Preferred Approach[e]	0	0	17,500	64,400 - 75,600	8,900 - 9,800	30,100	0	67,300	120,900 - 133,000
Option 2 Floor[e]	0	0	17,500	68,100 - 75,600	15,900 - 16,200	30,100	0	67,300	131,600 - 139,400
Option 3 Floor[e]	0	0	17,500	68,100 - 75,600	11,400 - 11,700	30,100	0	67,300	127,100 - 134,900

Notes:
a. Figures presented here include waste reallocated from systems that consolidate waste into other systems at the same facility.
b. Tons reallocated are incremental to that resulting from consolidation and market exit likely to occur in the baseline (e.g., without the proposed HWC MACT replacement standards).
c. Combusted hazardous waste reported to BRS in 1999: 3,558,004 tons.
d. Sector estimates may not total due to rounding.
e. Ranges reflect differences across pricing scenarios.

Employment Impacts

The proposed HWC MACT replacement standards are likely to cause employment shifts across hazardous waste combustion sectors. As combustion systems exit the market, workers at these locations may be displaced. At the same time, the rule may result in employment gains as new purchases of pollution control equipment stimulate additional hiring in the pollution control manufacturing sector and as additional staff are required at combustion facilities for various compliance activities. In the section below, we describe the approach for analyzing employment changes.[47] We then describe the results of this analysis for both employment gains and dislocations.

Primary employment dislocations in the combustion industry are likely to occur when combustion systems stop burning hazardous waste. For each system that stops burning, employment dislocations include operating and maintenance labor, as well as supervisory and administrative labor. Proportionately, we expect relatively minor employment dislocations at energy recovery systems (e.g., kilns, boilers, and industrial furnaces) and on-site incinerators. If these systems stop burning hazardous waste, they will still continue operating, but will use different fuels. In addition, energy recovery systems will need to maintain hazardous waste management staff to collect waste and prepare it for shipment to another location. Similarly, if an on-site incinerator shuts down, the facility will need workers on site to prepare waste for off-site shipment. The only jobs lost are those associated with the operation of the incinerator. In contrast, if a commercial incinerator exits the market, each worker at that facility are likely to lose his or her job since incineration is the facility's core business. Exhibit 5-11 outlines our methodology for estimating employment dislocations.

In addition to employment dislocations, the proposed HWC MACT replacement standards will also lead to job gains as firms make investments to comply with the requirements of the proposed HWC MACT replacement standards. Employment gains will occur in the pollution control equipment manufacturing industry, which produces devices to be used to achieve compliance with the standards. We also anticipate employment increases at combustion facilities as additional operation and maintenance will be required for the new pollution equipment and staff will be needed for other compliance activities, such as new reporting and record-keeping requirements. Our approach for estimating these gains is illustrated in Exhibit 5-12.

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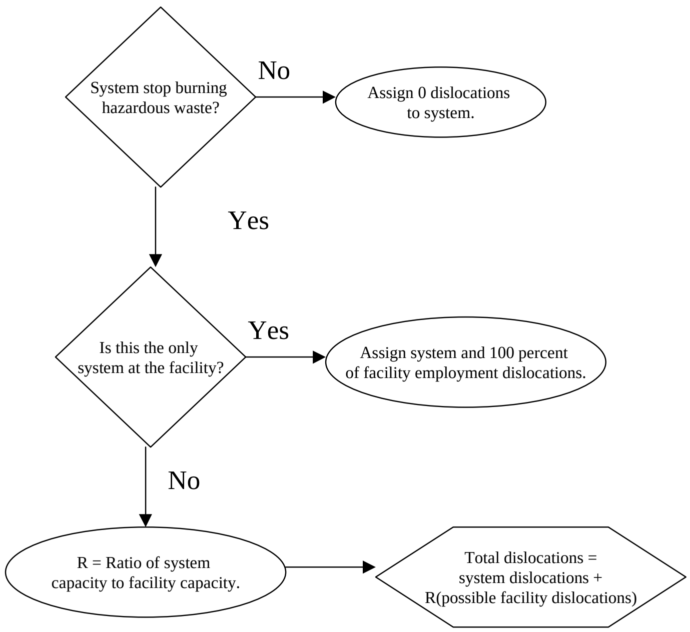
[47] See Appendix E for a more detailed discussion of the methodology for the employment impacts analysis.

Exhibit 5-11

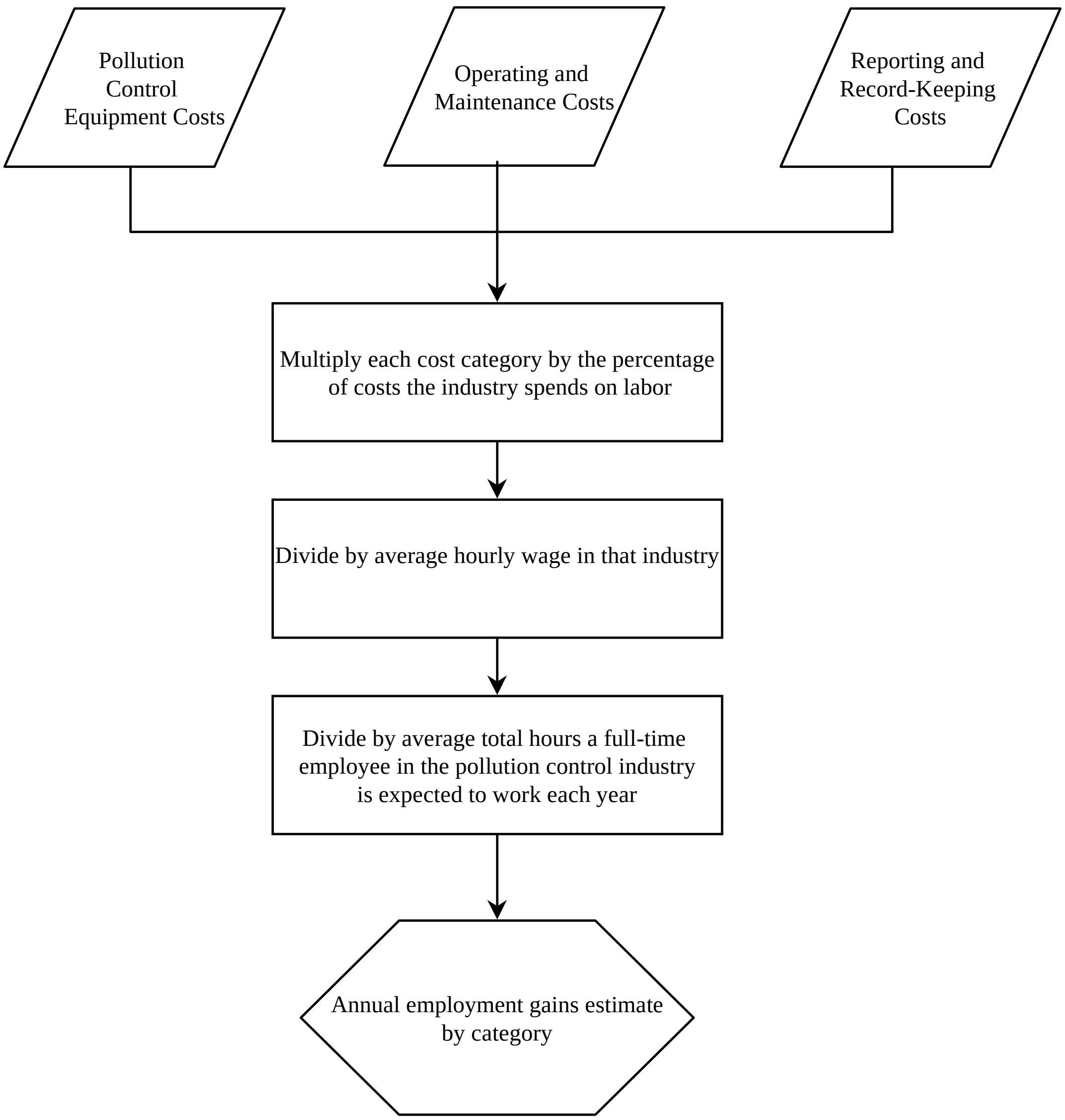
Procedure to Estimate Employment Dislocations



We normalize estimates of both employment gains and dislocations as full-time equivalent (FTE) employees on an annual basis. That is, short-term employment increases may occur in the pollution control equipment industry as combustion facilities make their initial equipment purchases. We average these surges over the lifetime of the pollution control equipment so that estimates of employment gains and dislocations are presented in consistent terms. Results from the employment impact analysis are summarized in Exhibits 5-13 and 5-14. We also describe these results in more detail below.

Exhibit 5-12

PROCEDURE USED TO ESTIMATE EMPLOYMENT GAINS



Employment Dislocation Results

In general, employment dislocations do not vary a great deal across the replacement MACT options. Total employment dislocations range from 387 to 417 FTEs under the Agency Preferred Approach. Employment dislocations increase to approximately 422 to 436 FTEs under the Option 2 Floor and to 416 to 430 FTEs under the Option 3 Floor.[48] Among the different combustion sectors, on-site incinerators are responsible for more than 60 percent of these job losses, which reflects both the large number of on-site incinerators in the universe as well as the relatively numerous exits expected within this sector. A significant portion of employment dislocations also occur at liquid boilers; under the Agency Preferred Approach these systems are responsible for approximately 25 percent of expected job losses.

Exhibit 5-13

SUMMARY OF ESTIMATED EMPLOYMENT DISLOCATIONS[a, b]

	Cement Kilns	LWAKs	Commercial Incinerators	On-site Incinerators	Liquid Boilers	Coal Boilers	HCl Prod. Furnace	TOTAL[d]
Option 1 Floor[c]	0	0	48	237 - 253	92 - 107	10	0	387 - 417
Agency Preferred Approach[c]	0	0	48	237 - 253	92 - 107	10	0	387 - 417
Option 2 Floor[c]	0	0	48	245 - 253	119 - 125	10	0	422 - 436
Option 3 Floor[c]	0	0	48	245 - 253	113 - 119	10	0	416 - 430

Notes:
a. Employment loss estimates are incremental, or directly attributable to the proposed HWC MACT replacement standards.
b. Employment impacts are national estimates and are based on primary impacts only. They ignore any secondary spill-over effects.
c. Ranges reflect differences across pricing scenarios.
d. Sums of individual sector dislocations may not equal total dislocations because of rounding.

[48] Employment dislocations are lower under the Option 3 Floor than under the Option 2 Floor because the former is not as stringent as the latter for all systems in the universe.

Employment Gain Results

Total annual employment gains associated with the Agency Preferred Approach range from 572 to 577 FTEs. Approximately 40 percent of these estimated job gains occur at facilities with liquid or solid boilers. An additional 33 percent of the employment gains occur in the pollution control equipment industry. Commercial combustion facilities are responsible for less than 15 percent of job gains, reflecting the relatively small number of these systems in the hazardous waste combustion universe.

Exhibit 5-14

SUMMARY OF ESTIMATED EMPLOYMENT GAINS[a, b]

MACT Option	Pollution Control Device Producers	Cement Kilns	LWAKs	Commercial Incinerators	On-site Incinerators	Liquid Boilers	Coal Boilers	HAPFs	TOTAL
Option 1 Floor[c]	175 - 177	43	3	14	41 - 43	199 - 201	11	12	497 - 502
Agency Preferred Approach[c]	190 - 192	43	29	14	41 - 43	199 - 201	33	24	572 - 577
Option 2 Floor[c]	294 - 295	149	6	18	50 - 51	233 - 234	11	14	774 - 777
Option 3 Floor[c]	307 - 308	141	7	18	47 - 48	303 - 304	11	14	848 - 851

Notes:
a. Estimates are sensitive to a number of assumptions, including the wage rates associated with compliance requirements and the percent of revenues generated due to each of the compliance requirements.
b. Estimates are national and based on primary employment impacts only, ignoring any secondary spill-over effects. Therefore, they do not account for job displacement across sectors as investment funds are diverted from other areas of the economy and should not be interpreted as net gains.
c. Ranges reflect differences across pricing scenarios.

Employment Impact Conclusions

Overall, a more stringent regulatory option will lead to both slightly higher job dislocations, as more systems are expected to stop burning, and more job gains, as compliance requirements stimulate additional hiring. While this analysis may suggest overall net job creation under particular options and within particular combustion sectors, such a conclusion is inaccurate. Because the gains and dislocations occur in different sectors of the economy, they should not be added together; doing so would mask important distributional effects of the rule. In addition, employment gain estimates only reflect sectoral impacts and therefore do not account for job displacement across sectors as investment funds are diverted from other areas of the economy.

Combustion Price Increases

All combustion facilities that remain in operation will experience increased costs under the MACT standards. To protect their profits, commercial combustion facilities will have an incentive to pass these increased costs on to their customers in the form of higher combustion prices. Generators potentially will have to pay higher prices unless they can obtain less expensive waste management alternatives.

Exhibit 5-15 illustrates how price pass-through would work in theory. This exhibit illustrates a number of important principles about hazardous waste combustion markets.

- Waste will be sent to the least expensive alternatives first, all else being equal.[49]

- Both baseline costs of hazardous waste combustion and new compliance costs vary significantly across combustion systems, even within the same sector. Thus, regulatory changes can affect different systems in very different ways.

- Prices will rise to the point at which all demand for hazardous waste combustion is met, which depends on the cost of alternatives to combustion. In Exhibit 5-15, the combustion market price cannot exceed $230 per ton; otherwise generators engage in the less costly alternative of waste

[49] In fact, other factors such as transportation costs will affect which facilities are the least expensive to particular generators. In addition, the price of combustion will vary by the method of delivery (e.g., bulk versus drum), the form of the waste (e.g., liquid versus solid), and the contamination level (e.g., metals or chlorine content). These factors make it more difficult to compare various waste management options.

minimization.[50] At a price of $230 per ton, facilities with waste management costs of less than $230 per ton (systems A, B, and C) earn a profit because combustion is then a viable alternative to waste minimization. Since waste generators are indifferent between paying $230 per ton for combustion services and engaging in waste minimization at a cost of $230 per ton, $230 is the market clearing price of combustion services.

Exhibit 5-15

SIMPLIFIED EXAMPLE OF DETERMINATION OF NEW MARKET PRICE FOR COMBUSTION

Assume 100 Tons Require Management	Combustion System A	Combustion System B	Combustion System C	Waste Minimization	Combustion System D
Treatment Cost/ton	$145	$175	$220	$230	$240
Capacity (tons)	35	25	35	100	300
Remaining tons requiring treatment	100-35=65	65-25=40	40-35=5	5-5=0	0

The real hazardous waste combustion marketplace is much more complex than the example above. Estimating the market clearing price of combustion is difficult due to pricing variations by region, waste stream, and individual combustion service providers. Instead, we have adopted some simplifying assumptions that should allow for a reasonable approximation of price changes in combustion markets.

As indicated in the "Modeling Market Dynamics" section above, we assume that demand for hazardous waste combustion is inelastic because of the relatively high cost of combustion alternatives.[51] Available economic data on the cost of waste management alternatives, including source reduction and other waste minimization options, are not precise enough for us to pinpoint the maximum price increase that combustors could pass through to generators. However, based on the analysis of waste management alternatives (summarized in Chapter 6), we believe that demand for combustion may be sufficiently inelastic for commercial combustion facilities to pass through 100

[50] The $230 per ton estimate in Exhibit 5-15 is presented for illustrative purposes only. It does not necessarily reflect the actual cost of waste minimization.

[51] As described above, in an analysis conducted for the 1999 *Assessment*, we estimated that as much as 240,000 tons of waste would be reallocated to waste minimization in response to higher prices. However, approximately 100,000 tons have been reallocated to waste minimization. In addition, given current combustion pricing, the market is now on the inelastic portion of the demand function, as illustrated above in Exhibit 5-3.

percent of their compliance costs. However, it is also true that most commercial combustion systems have available capacity and that commercial systems may face competition from facilities in other countries. We therefore conducted a sensitivity analysis where prices do not deviate from their baseline levels.

Ideally, we would estimate new prices based on the cost increase of the marginal combustion system (e.g., the most costly system required to meet market demand). Given the uncertainty associated with estimates of baseline and incremental compliance costs, however, we have decided not to rely on point estimates associated with one individual system. Instead, we rely on the cost estimates of all commercial combustion systems and calculate the percent price increase necessary for the sector as a whole to recover its compliance costs (e.g., the total compliance cost recovery scenario described in the "Modeling Market Dynamics" section of this chapter). Under this scenario, we assume the same percentage price increase for all waste forms.[52] However, as described above, prices may not change for several reasons; therefore, we consider a scenario where prices remain constant.[53]

Exhibit 5-16 shows the increased prices estimated with a 100 percent cost pass-through. Under the Agency Preferred Approach, the price increase is approximately 1.4 percent. The most significant price increase (2.9 percent) occurs under the Option 2 Floor. International and regional competition could mitigate any potential price increases. In the face of higher prices, waste generators may consider sending waste to treatment facilities in Canada, Mexico, or Europe. BRS data show that some U.S. waste generators already do so.

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[52] This assumption may not reflect actual changes, as combustion prices for more contaminated waste forms may increase by a higher percentage.

[53] In this scenario, we assume the market for burning halogenated waste is segmented, with commercial kilns charging a halogen premium of approximately 11.9 percent of that charged by commercial incinerators. Chapter 3 provides further information on the segmentation of this market.

Exhibit 5-16

COMBUSTION PRICES PER TON DUE TO ASSUMED PRICE PASS THROUGH

MACT Options	Halogenated Liquids	Non-halogenated Liquids	Gases	Halogenated Sludge	Non-halogenated Sludge	Lab Packs	Halogenated Solids	Non-halogenated Solids
Baseline Prices	$1,080	$127	$940	$1,010	$560	$2,820	$1,068	$557
Option 1 Floor[a]	$1,092	$128	$950	$1,021	$566	$2,851	$1,079	$563
Agency Preferred Approach[a]	$1,096	$129	$953	$1,024	$568	$2,860	$1,082	$565
Option 2 Floor[a]	$1,112	$131	$968	$1,040	$577	$2,903	$1,099	$574
Option 3 Floor[a]	$1,111	$131	$967	$1,039	$576	$2,900	$1,097	$573

Notes:
a. Ranges reflect total cost recovery and maximum price increase scenarios.

Other Industry Impacts

Combustion Profit Changes. Profits for commercial combustion facilities could increase as a result of the proposed HWC MACT replacement standards, whereas profitability for on-site systems will likely fall.[54] Under the Agency Preferred Approach, commercial incinerator profits are estimated to increase by approximately 7.7 percent. These additional profits are due largely to increased waste treatment revenues from generators that decide to send their waste off site in response to the proposed HWC MACT replacement standards. In contrast, the profits of cement kiln hazardous waste burning operations are estimated to remain relatively constant, and LWAK waste burning profits are expected to fall by 5.3 percent, which reflects relatively high per system compliance costs at these facilities. Adequate data are not available to measure changes in boiler and on-site incinerator profitability. However, since these systems receive no additional waste because of the proposed HWC MACT replacement standards, their profitability will likely decline.[55]

Cost Structure of the Combustion Industry. Incremental compliance and off-site disposal expenditures associated with the proposed HWC MACT replacement standards represent less than 0.14 percent of the total pollution control expenditures at facilities with on-site incinerators.[56] This estimate does not reflect the O&M savings of facilities that close an on-site incinerator. Compliance expenditures associated with the proposed HWC MACT replacement standards are expected to increase total pollution control expenditures by approximately 11.9 percent at cement kilns that treat hazardous waste.[57] Total costs of waste-burning increase by more than 14 percent for cement kilns under the Agency Preferred Approach, while total waste burning costs increase by about 47 percent for LWAKs.[58] Commercial incinerator hazardous waste treatment costs increase by approximately 3.9 percent as a result of the proposed HWC MACT replacement standards. However, overall costs still remain significantly lower for hazardous waste burning cement kilns when compared to commercial incinerators.

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[54] On-site incinerator profitability is the difference between the cost of sending waste off site, including disposal fees and transport costs, and the cost of treating waste on site. Chapter 3 contains a detailed description of our methods for assessing system profitability.

[55] Our profitability analysis considers only operating profits associated with burning hazardous waste (e.g., total sales minus operating costs). It does not examine overall company performance and post-tax profits.

[56] We use the baseline pollution control expenditures for these facilities as given in the 1999 *Assessment*, which relied on the 1994 Pollution Abatement and Control Expenditure (PACE) survey results. In the report for the final HWC MACT replacement standards, we will update this estimate to reflect more recent PACE data. We did not include commercial incinerators in this cost structure analysis because the *Pollution Abatement Costs and Expenditures* reports do not provide data on waste service industries (the industry category for commercial incinerators).

[57] According to *Pollution Abatement Costs and Expenditures: 1999*, the total pollution expenditures for the cement industry in 1999 were $301.70 million, which is $318.9 million in 2002 dollars using the GDP implicit price deflator. Because only 19 percent of cement kilns burn hazardous waste, we attribute $60.6 million to cement kilns that burn hazardous waste (0.19 * $318.9). However, costs reported in PACE do not account for the 2002 Interim Standards, which require hazardous waste burning cement kilns to spend an additional $11.2 million per year on pollution controls.

[58] These estimates do not account for energy savings at cement kilns and LWAKs that receive additional waste from boilers that stop burning hazardous waste.

APCD Profit Increases. To comply with the MACT standards, many facilities will need to purchase additional pollution control equipment. From the perspective of the pollution control industry, these expenditures are translated into additional revenues and profits. We estimate that additional profits for the APCD industry will total approximately $795,700, or about $80,000 annually (undiscounted). This total figure represents about 11.8 percent of the average annual profits of one of the largest APCD manufacturers between 1998 and 2002.[59]

Economic Impact Summary

In this chapter, we presented analyses of and results for several different economic impacts expected to result from the proposed HWC MACT replacement standards. We summarize the findings in Exhibit 5-17 and describe major results below:

- Across MACT options, no cement kilns, LWAKs, or HCl production furnaces will stop burning hazardous waste. Two commercial incinerator systems and between 32 and 34 on-site incinerators will stop burning hazardous waste entirely, rather than incur the rule's compliance costs. In addition, the proposed HWC MACT replacement standards will result in the closure of 24 to 27 boilers.

- For the Agency Preferred Approach, market exit and waste consolidation activity is expected to result in up to 133,000 tons of waste that will be reallocated from combustion systems that stop burning. This quantity corresponds to 3.7 percent of total combusted wastes. Under the Option 2 Floor, the quantity of reallocated waste may increase to 139,400 tons. Across replacement MACT options, the reallocated wastes come primarily from on-site incinerators that exit the market. There is currently adequate capacity available at commercial facilities to absorb this extra waste.

- As some systems stop burning hazardous waste and others invest in additional pollution control and monitoring equipment, employment shifts will occur. At systems that consolidate waste burning activities or that stop burning altogether, employment dislocations of between 387 and 417 full-time equivalent employees are expected. More than 60 percent of these dislocations occur among on-site incinerators and more than 25 percent of job losses occur at liquid and coal boilers. Employment dislocations do not vary significantly across different MACT replacement options. Employment gains of approximately 192 full-time equivalent employees are expected in the pollution control industry under the Agency Preferred Approach, and gains of approximately 385 full-time equivalent employees are expected at

[59] To estimate additional profits for APCD manufacturers, we multiply total capital costs post-MACT by the average profit percentage of net sales for a major APCD manufacturer. (We calculate the average profit percentage of net sales (after all costs and taxes) for the APCD manufacturers with data from the firms' 10-k forms.)

combustion facilities that continue waste burning as facilities invest in new pollution control equipment. Gains similarly increase by approximately 47 percent from the Agency Preferred Approach to the Option 3 Floor.

- As combustion facilities incur compliance costs, they have an incentive to increase prices for combustion. Our evaluation of waste management alternatives suggests that combustion demand is relatively inelastic and prices will likely increase as a result of the final rule by 1.4 percent.

- Compliance costs associated with the proposed HWC MACT replacement standards increase the total costs of burning hazardous waste by approximately 14 percent for cement kilns, 47 percent for LWAKs, and 4 percent for commercial incinerators, though overall costs remain much lower for cement kilns. MACT compliance costs represent less than 0.14 percent of total pollution control expenditures in industries that contain facilities with on-site incinerators. Despite these compliance costs, most commercial systems do not bear significant net costs because of the rule, since several generators may now send their waste to commercial facilities.

Exhibit 5-17

SUMMARY OF ECONOMIC IMPACT ANALYSIS

	Replacement MACT Option			
Economic Impact Measure	**Option 1 Floor**	**Agency Preferred Approach**	**Option 2 Floor**	**Option 3 Floor[b]**
Market Exits (systems)				
Cement Kilns	0	0	0	0
Commercial Incinerators[a]	2	2	2	2
LWAKs	0	0	0	0
On-Site Incinerators[a]	32 - 34	32 - 34	33 - 34	33 - 34
Liquid Boilers[a]	22 - 25	22 - 25	29 - 30	27 - 28
Coal Boilers[a]	2	2	2	2
HCl Production Furnaces	0	0	0	0
Quantity of Waste Reallocated[a] (U.S. tons)	120,900 - 133,000	120,900 - 133,000	131,600 - 139,400	127,100 - 134,900
Employment Impacts				
Annual Gains[a]	497 - 502	572 - 577	774 - 777	848 - 851
Annual Dislocations[a]	387 - 417	387 - 417	422 - 436	416 - 430
Expected Combustion Price Change[a]	1.1%	1.4%	2.9%	2.8%

Notes:

a. Ranges reflect differences across pricing scenarios.

b. Impacts may not be as significant under the Option 3 Floor because the replacement standards proposed for this option are not as stringent for some systems. The Option 2 Floor standards for metals and chlorine are set based on "thermal emissions" (e.g., stack gas emissions divided the energy content of the hazardous waste feed). In contrast, the Option 3 Floor standards for metals and chlorine are based solely on stack gas emissions, regardless of waste feed. Under these conditions, a system with low overall stack gas emissions would incur relatively low costs under the Option 3 Floor. However, the same system may incur higher costs under Option 2 than under Option 3 if its waste feed has a low energy content.

NOTE: *After this Assessment was prepared, the Agency modified its proposal for the HWC MACT replacement standards. The benefits analysis presented in this chapter does not reflect this change. Information on the costs, benefits, and other impacts of EPA's proposed HWC MACT replacement standards is available in EPA, "Addendum to the Assessment of the Costs, Benefits, and Other Impacts of the Hazardous Waste Combustion MACT Standards: Proposed Rule," March 2004. This document can be found in the docket.*

NOTE: This chapter does not provide quantified or monetary estimates of the benefits associated with reduced dioxin emissions. However, estimates of the benefits associated with reduced dioxin emissions under the revised proposal for the HWC MACT replacement standards are available in EPA, "Addendum to the Assessment of the Costs, Benefits, and Other Impacts of the Hazardous Waste Combustion MACT Standards: Proposed Rule," March 2004. This document can be found in the docket.

BENEFITS ASSESSMENT — CHAPTER 6

This chapter presents the benefits assessment for the proposed HWC MACT replacement standards. To evaluate incremental benefits to society of emission reductions at hazardous waste combustion facilities we use results from EPA's 1998 multiple pathway human health and ecological risk assessment updated to address incremental benefits of the replacement standards (e.g., assuming that the 2002 interim standards are in place).[1] This chapter also briefly discusses how the proposed MACT replacement standards may potentially lead to changes in the types and quantities of wastes generated and managed at combustion facilities through increased waste minimization.

[1] We did not include an analysis to assess the potential magnitude of property value benefits caused by the MACT standards due to limitations of the benefits transfer approach and because property value benefits likely overlap with some human health and ecological benefits. As a result, including property value benefits may result in double-counting. The benefits assessment also does not examine how secondary impacts such as emissions from increased coal use at combustion sources that stop burning hazardous waste as fuel may result in human health and ecological damages.

The chapter is organized into eight sections:

- **Risk Assessment Overview:** Provides a brief summary of the methodology and key results from the multiple pathway risk assessment which forms the basis for the human health and ecological benefits assessment.

- **Human Health Benefits Analysis:** Describes the approach and presents results for characterizing human health benefits from the risk results. Where possible, we assign monetary values to these risk reductions using different economic valuation techniques. We also describe benefits to sensitive sub-populations in quantitative, non-monetary terms.

- **Visibility:** Describes the approach and presents results for characterizing visibility improvements. We assign monetary values to these improvements using economic valuation techniques.

- **Ecological Benefits Analysis:** Describes the methodology and results from the 1999 standards ecological benefits assessment and provides a comparison to the expected ecological benefits of the replacement standards.

- **Forest Health and Aesthetics:** Describes the impacts of HAPs on forest ecosystems and provides examples of forest health and aesthetics benefit assessments. Forest health and aesthetics benefits results are described in qualitative terms due to the lack of research linking measurable effects of HAPs on forest ecosystems.

- **Agricultural Productivity:** Describes the potential effects of emissions on agricultural productivity. Agricultural productivity benefits are described in qualitative terms as little research has been done on the effects of the compounds of concern in this analysis.

- **Waste Minimization Benefits:** Describes the benefits, if any, that the replacement MACT standards may have on increasing waste minimization practices.

- **Conclusions:** Summarizes key findings from the benefits assessment.

This benefits analysis builds upon the results and discussions presented in the 1999 *Assessment* and the 1999 Addendum. These documents are cited as source material for the current analysis because they generally provide a reasonable approximation of the 2002 Interim Standards baseline. However, it is important to note that the 2002 Interim Standards, not the 1999 standards, represent the baseline for the HWC MACT replacement standards. When the 1999 analyses are used to approximate the 2002 baseline, this Assessment identifies the necessary adjustments.

It is also important to note that the benefits analysis assumes a baseline scenario with constant future capacity and with combustion facilities operating at levels corresponding to trial burn performance. As explained in the "Regulatory Baseline" chapter, the characteristics of waste fed during normal operations may differ significantly from that fed during trial burns. In particular, facilities often "spike" the waste feed at the trial burns with high levels of metals, chlorine, and mercury. This situation results in emission estimates that likely exceed "typical" emissions. Therefore, the risk reductions and benefits estimates may overstate true benefits. Conversely, if significant numbers of facilities cease burning waste altogether, then risk reductions at those facilities may in some cases be greater than this analysis assumes.

BENEFITS QUANTIFICATION OVERVIEW

The basis for the quantitative benefits assessment is an extrapolation of particulate matter (PM) benefits estimated for the 1999 standards in the 1999 *Assessment*.[2] This section provides an overview of the methods used to extrapolate the incremental benefits of the replacement standards from those estimated for the 1999 standards. Any comparison of the 2002 interim standards, currently in place, to the proposed HWC MACT replacement standards is complicated. No separate risk assessment was conducted for the interim standards. In general, because the interim standards involved only modest changes from the 1999 standards the benefits for the interim standards are likely to be similar in magnitude to the 1999 standards. Therefore, we assume that the benefits estimates in the 1999 *Assessment* are a reasonable proxy for benefits realized under the 2002 interim standards.

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[2] Although we extrapolate benefits from the estimates presented in the 1999 *Assessment* and the 1999 Addendum, the 2002 Interim Standards serve as the baseline of our analysis. The 2002 Interim Standards are generally similar to the standards examined in the 1999 *Assessment* and Addendum; therefore, these 1999 analyses serve as a reasonable approximation of the 2002 Interim Standards baseline.

For the 1999 *Assessment*, we estimated the avoided incidence of mortality and morbidity associated with reductions in PM emissions.[3] The risk assessment developed estimated cases of mortality and morbidity avoided for children and the elderly, as well as the general population, using concentration-response functions derived from human epidemiological studies available in 1998. Morbidity effects included respiratory and cardiovascular illnesses requiring hospitalization, as well as other illnesses not requiring hospitalization, such as acute and chronic bronchitis and acute upper and lower respiratory symptoms. The risk assessment also estimated decreases in PM-related minor restricted activity days (MRADs) and work loss days (WLDs). Rates of avoided incidence, work days lost, and days of restricted activity were estimated for each of 16 sectors surrounding a facility using the concentration-response functions and sector-specific estimates of the corresponding population and model-derived ambient air concentration, either annual mean PM_{10} or $PM_{2.5}$ concentrations or distributions of daily PM_{10} or $PM_{2.5}$ concentrations, depending on the concentration-response function. The sectors were defined by four concentric rings out to a distance of 20 kilometers (about 12 miles), each of which was divided into four quadrants. The sector-specific rates were weighted by facility-specific sampling weights and then summed to give the total incidence rates for a given source category.[4]

To assess the benefits of the proposed HWC MACT replacement standards, we took the avoided incidence estimates from the 1999 *Assessment* and adjusted them to reflect both the PM emission reductions projected to occur under the replacement standards (incremental to the 2002 Interim Standards), and changes in the universe of facilities burning hazardous wastes since the 1999 *Assessment*. For cement kilns, lightweight aggregate kilns, and incinerators, the estimates were made by adjusting the respective estimates at the source category level by the ratio of emission reductions (for the replacement standards vs. the 1999 standards) and the ratio of the number of facilities affected by the rules (facilities currently burning hazardous wastes vs. facilities burning hazardous wastes in the 1999 *Assessment*).[5] For liquid and solid fuel-fired boilers and hydrochloric acid production furnaces, we extrapolated the avoided incidence from the incinerator source category using a similar approach, except that the ratios of the exposed populations were used (corresponding to the concentration-response functions from the 1999 *Assessment*), instead of the number of facilities.

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[3] See "Human Health and Ecological Risk Assessment Support to the Development of Technical Standards for Emissions from Combustion Units Burning Hazardous Wastes: Background Document" November 1998.

[4] It should be noted that the avoided incidence estimates were based entirely on the incremental decrease in ambient air concentrations associated with emission controls on the hazardous waste sources subject to the 1999 rule. Background levels of PM were assumed to be sufficiently high to exceed any possible threshold of effect but ambient background levels of PM were not otherwise considered in the analysis.

[5] To account for the increase in population since the 1990 census was taken, we also adjusted the avoided incidence estimates by the ratio of the population at the national level (corresponding to the concentration-response function) for the year 2000 census vs. the 1990 census.

We estimated the exposed populations for hazardous waste-burning boilers and HCl production furnaces using the same GIS methods as the 1999 *Assessment* (e.g., a 16 sector overlay). Nonetheless, the extrapolated estimates are subject to additional uncertainty, especially for solid fuel-fired boilers and HCl production furnaces because these two source categories have only a small number of facilities and may be poorly represented by the incinerator facilities analyzed in the 1999 *Assessment*.

It is important to note that the proposed HWC MACT replacement standards are incremental to the previous (2002 interim) rule. Therefore, benefits are more modest than the 1999 estimates because the baseline reflects the implementation of the rule similar to the 1999 rule, and assumes that a significant portion of the benefits estimated in the 1999 *Assessment* have already been captured. Although the benefits estimated in this analysis are expected to be more modest than those estimated in the 1999 *Assessment* the benefits captured by both analyses represent only a portion of the benefits associated with this rule. Specific ecological and human health benefits are not captured because of lack of research linking measurable effects of HAPs on human and ecosystem health and ecosystems.

The benefits estimates in this assessment are presented as point estimates instead of in probabilistic terms.[6] Although probabilistic estimates would provide valuable information about the uncertainty associated with the benefits of the proposed HWC MACT replacement standards, probabilistic analysis was not amenable to our methodology of adjusting the benefits estimates presented in the 1999 *Assessment*, which were not expressed in probabilistic terms. In certain cases, however, we present monetized estimates as a range to reflect uncertainty in valuation techniques.

RISK ASSESSMENT OVERVIEW

The basis for the 1999 benefits *Assessment* was a multiple-pathway risk assessment developed by the Economics, Methods and Risk Analysis Division in EPA's Office of Solid Waste. This risk assessment was designed to estimate baseline risks from hazardous waste combustion emissions, as well as expected risks after the 1999 MACT standards were implemented.[7] This section provides an overview of the risk assessment, which analyzed both human health and ecological risks that result from direct and indirect exposure to emissions from facilities that burn

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[6] OMB guidance recommends that federal agencies conduct probabilistic assessments of the benefits associated with new regulation. Office of Management and Budget. *Informing Regulatory Decisions: 2003 Report to Congress on the Costs and Benefits of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities*. 2003.

[7] "Human Health and Ecological Risk Assessment Support to the Development of Technical Standards for Emissions from Combustion Units Burning Hazardous Wastes: Background Document - Final Report," November 1998.

hazardous waste.[8] A multiple pathway analysis that models both inhalation and ingestion pathways was used to estimate human health risks.[9] The *Assessment* used a statistically-based stratified random sampling approach in which 76 hazardous waste combustion facilities and their site-specific land uses and environmental settings were characterized.[10] The randomly selected facilities in the study included: 43 on-site incinerators, 13 commercial incinerators, 15 cement kilns, and five lightweight aggregate kilns.[11] The current *Assessment* adjusts the estimates from the 1999 *Assessment* to project the human health benefits of the replacement standards.

The pollutants analyzed in the risk assessment included dioxins and furans, selected metals, and PM.[12] The metals modeled in the *Assessment* include the following: antimony, arsenic, barium, beryllium, cadmium, chromium copper, cobalt, lead, manganese, mercury, nickel, selenium, silver, and thallium.[13] The risk assessment modeled fate and transport of the emissions of these pollutants to arrive at concentrations in air, soil, surface water, and sediments. To assess human health risks, these concentrations can be converted to estimated doses to the exposed populations using exposure factors such as inhalation and ingestion rates. These risk assessment calculated cancer and non-cancer risks using these doses, if the appropriate health benchmarks were available.

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[8] The Agency expects that hazardous waste-burning kilns that are able to use feed control to achieve emissions reductions will also generate cement kiln dust (CKD) with a lower toxicity than prior to feed control (in particular, lower SVM content) (USEPA "Selection of MACT Standards and Technology," Chapter 12 of Volume 3 Technical Support Document for HWC MACT Standards, July 1999.) The risk assessment did not address the potential human health and ecological benefits associated with reduced toxicity CKD.

[9] A less detailed screening-level analysis was used in the 1999 *Assessment* to identify the potential for ecological risks.

[10] For a more detailed discussion of the land use characterization, see: Zachary Pekar and Tony Marimpietri, "Description of Methodologies and Data Sources Used in Characterizing Land Use (including Human/Livestock Populations), Air Modeling Impacts, and Waterbody/Watershed Characteristics for HWC Study Areas," Memorandum, Prepared for David Layland, U.S. Environmental Protection Agency, 27 January 1998.

[11] According to the risk assessment, the random sample of 65 facilities ensures that the probability of modeling at least one high-risk facility is 90 percent. The other 11 combustion facilities were selected for the risk assessment at Proposal. Because these 11 facilities were not selected at random, they are handled differently from the 65 randomly selected facilities in extrapolating risks to reflect the universe of facilities.

[12] PM is not evaluated in the screening for ecological risks. Also, the national risk assessment did not include an assessment of the risk posed by nondioxin products of incomplete combustion (PICs) due to the lack of sufficient emission measurements.

[13] Includes divalent mercury (via ingestion), elemental mercury (via inhalation), and methyl mercury (via ingestion). We recognize that these chemicals are not all HAPs; however, the risk assessment analyzed all chemical constituents covered by the rule for which sufficient data were available. Both chromium (III) and chromium (VI) were evaluated in the risk assessment.

This *Assessment* provides a discussion of the ecological benefits that may be associated with the replacement standards by comparing emissions reductions to the reductions from the 1999 standards. In the 1999 *Assessment,* soil, surface water and sediment concentrations were compared with eco-toxicological criteria representing protective screening values for ecological risks to assess potential ecological risks.[14] Because these criteria were based on *de minimis* ecological effects and thus represented conservative values, an exceedence of the eco-toxicological criteria did not necessarily indicate ecological damage; it simply suggested that potential damages could not be ruled out.

To characterize the non-cancer risks to the populations listed above, the 1999 risk assessment broke down the area surrounding each modeled combustion facility into 16 polar grid sectors, as illustrated in Exhibit 6-1. For each polar grid sector, risk estimates were developed for different age groups and receptor populations (e.g., 0-5 year old children of subsistence fishers). This approach was used because geographic and demographic differences across polar grid sectors lead to sectoral variation in individual risks. Thus, individual risk results are aggregated across sectors and weighted by population in each sector to generate the distribution of risk to individuals in the affected area.[15] An additional Monte Carlo analysis was conducted to incorporate variability in other exposure factors such as inhalation and ingestion rates.

HUMAN HEALTH BENEFITS

This section describes in greater detail the approaches for characterizing human health benefits. The starting point for assessing benefits is identifying those pollutants for which emission reductions are expected to result in improvements to human health or the environment. We then summarize the relevant results from the risk assessment for the pollutants of concern, focusing on population risk results based on central tendency exposure parameters so that benefits can be appropriately compared with total costs. We express the risk assessment data as indicators of potential benefits, such as reduced potential for developing particular illnesses. Where possible, we assign monetary values to these benefits using a benefits transfer approach.

<u>Human Health Benefits Methodology</u>

The approach for assessing human health benefits is divided into two components — benefits from cancer risk reductions and benefits from non-cancer risk reductions. We separate the discussion in this way because the interpretation of risk reductions for carcinogenic pollutants is very different than that for non-carcinogens. As explained above, for both cancer and non-cancer

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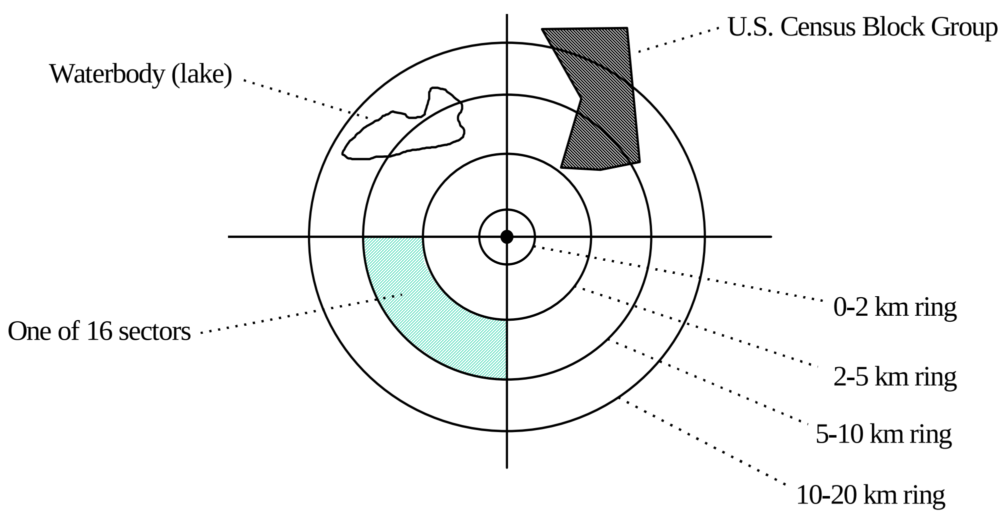
[14] The methodology used to develop the eco-toxicological criteria is largely a product of the ecological risk assessment work conducted to support the proposed HWIR for process waste.

[15] Some of the exposure levels will not be sector specific (e.g., exposure to dioxin in dairy products is based on an average concentration at dairies throughout the entire study area.)

benefits, we focus on population risks because these results form the basis for assessing total benefits of the proposed HWC MACT replacement standards. In general, these results concern the population overall with regards to different age groups, though risk reductions associated with certain pollutants, such as lead, specifically affect children within the population. In these cases, we focus on the benefits to a subset population, ages 0-19.

Exhibit 6-1

DIAGRAM OF 16 SECTOR POLAR-BASED GRID USED IN THE RISK ASSESSMENT



In addition to population results, we also describe individual risk results for the hypothetical worst case scenarios for both cancer and non-cancer risks. Because we do not have population data for the most sensitive sub-populations, we can only describe individual risk results for subsistence farmers and fishermen and cannot make statements concerning the total number of people that may experience health benefits associated with the proposed HWC MACT replacement standards.

Approach for Assessing Benefits from Cancer Risk Reductions

In this analysis we discuss the potential cancer risk reductions by comparing the replacement standards to the results of the 1999 *Assessment*. The basic approach for assessing benefits from cancer risk reductions in the 1999 *Assessment* relied on two analytic components. First, the risk assessment estimated cancer risk reductions for all non-subsistence receptors in the vicinity of combustion facilities. These risk reduction estimates were derived from the median individual risk values and population data for non-subsistence population.[16] Carcinogens included in the risk assessment were dioxins/furans, arsenic, beryllium, cadmium, chromium (VI), and nickel. Second, the risk assessment estimated cancer risk reductions associated with the ingestion of dioxin-contaminated foods grown or raised near combustion facilities but distributed nationwide. We then calculated total cancer risk reductions by summing the avoided cases in communities near combustion facilities with the number of cases avoided due to reduced dioxin in the national food supply.[17] That is,

Total cancer risk reductions = *Avoided cases in communities near combustion facilities + Avoided cases due to reduced dioxin in the national food supply.*

The Addendum to the1999 *Assessment* estimated 0.36 cancer deaths would be avoided annually with a reduction of 28.7 grams of dioxins/furans emissions per year. The replacement standards will reduce dioxins/furans emissions by 0.4 grams annually for each of the Floor options and 4.7 grams annually for the Agency Preferred Approach (Exhibit 6-3). Thus, the replacement standards are expected to avoid less than 0.36 cancer deaths annually.

To assign monetary values to cancer risk reduction estimates, we apply the value of a statistical life (VSL) to the risk reduction expected to result from the replacement MACT standards. The VSL is based on an individual's willingness to pay (WTP) to reduce a risk of premature death or their willingness to accept (WTA) increases in mortality risk. There are many different estimates of VSL in the economic literature. Viscusi[18] presents 26 policy-relevant value-of-life studies. These range from \$0.80 million to \$18.23 million, with an average value of \$6.42 million (in 2002 dollars).[19] For this analysis we are altering the value of a statistical life (VSL) to reflect new information in the ongoing academic debate over the appropriate characterization of the value of

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[16] Cancer incidence estimates used direct and indirect exposure pathways for all non-subsistence receptors, excluding recreational anglers. Population risks could not be calculated for recreational anglers because detailed population data were not available for this receptor population.

[17] In a December 30, 1997 benefits methodology memorandum, we noted that summing these estimates may pose the potential for double-counting, considering that dioxin-contaminated food ingestion is also evaluated on the local level (Industrial Economics, Incorporated, Social Science Discussion Group. *Handbook for Non-Cancer Valuation: Draft.* Prepared for U.S. EPA, 1997, as cited in U.S. EPA, *Assessment of the Potential Costs, Benefits, and Other Impacts of the Hazardous Waste Combustion MACT Standards: Final Rule*, Office of Solid Waste, July 1999). However, if we make the assumption that most of the agriculture products produced within 20 kilometers of the facility are consumed outside the local area, then we minimize the double-counting potential. A follow-up phone call with EPA and Research Triangle Institute, the contractor that prepared the Combustion Risk Assessment, confirmed that this in fact is a reasonable assumption.

[18] Viscusi, W. Kip. *Fatal Tradeoffs: Public and Private Responsibilities for Risk*. New York: Oxford University Press, 1992.

[19] VSL was converted to 2002 dollars using the Consumer Price Index for all goods. WTP estimates are converted using the Consumer Price Index for all goods, while cost of illness estimates are converted using the Consumer Price Index for medical expenditures only.

reducing the risk of premature mortality. We are characterizing the VSL distribution in a more general fashion, based on two recent meta analyses of the wage-risk-based VSL literature. The new distribution is assumed to be normal, with a mean of $5.5 million (in 1999 dollars) and a 95 percent confidence interval between $1 and $10 million.[20,21] To value the mortality risk reductions, we multiply the expected number of annual premature statistical deaths avoided by the high-end, low-end, and mean value of the VSL estimates. The Agency welcomes public comment on the appropriate methodology for valuing reductions in the risk of premature death.

Approach for Assessing Benefits from Non-Cancer Risk Reductions

A variety of approaches are used to evaluate the benefits of reducing particulate matter, for which we estimate both morbidity and mortality benefits.[22] For lead and mercury, we compare the replacement standards to the results of the 1999 *Assessment*. In the 1999 *Assessment* we used upper bound estimates of the population at risk because we only had information on the *potential* of an adverse effect and we could not say anything about the *likelihood* of the effects.

We assign monetary values to non-cancer benefits using a direct cost approach which focuses on the expenditures averted by decreasing the occurrence of an illness or other health effects. While the WTP approach used for valuing the cancer risk reductions is conceptually superior to the direct cost approach, measurement difficulties, such as estimating the severity of various illnesses, preclude us from using this approach here. Direct cost measures are expected to understate true benefits because they do not include cost of pain, suffering, and time lost. On the other hand, because we use upper bound estimates of the population at risk, we cannot conclude that the results are biased in one direction or the other.

Benefits from Reduced Exposure to Particulate Matter

Epidemiological studies have linked PM (alone or in combination with other air pollutants) with a series of health effects.[23] PM can accumulate in the respiratory system and aggravate health problems such as asthma, or it can penetrate deep into the lungs and lead to even more serious health

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[20] U.S. EPA *Benefits of the Proposed Inter-State Air Quality Rule,* January 2004. Pg. 4-65.

[21] This mean value and range are consistent with estimates presented in U.S. EPA, *Benefits of the Proposed Inter-State Air Quality Rule*, January 2004, inflation adjusted.

[22] Particulate matter is the only other pollutant in the risk assessment for which there is sufficient dose-response information to estimate numbers of cases of disease and deaths from exposures.

[23] The benefits discussion that follows in the rest of this paragraph is adapted from EPA, *Regulatory Impact Analysis of the Final Industrial Boilers and Process Heaters NESHAP: Final Report*, February 2004.

problems. These health effects include premature death, respiratory symptoms and disease, diminished lung function, and weakened respiratory tract defense mechanisms. Children, the elderly, and people with cardiopulmonary disease, such as asthma, are most at risk from these health effects.

Since performing the risk assessment for the 1999 *Assessment*, EPA has updated its benefits methodology to reflect recent advances in air quality modeling and human health benefits modeling. To estimate PM exposure for the 1999 risk assessment, the Agency used the Industrial Source Complex Model-Short Term Version 3 (ISCST3). More recent EPA benefits analyses have used more advanced air-quality models. For example, the Agency's assessment of the industrial boilers and process heaters NESHAP used the Climatological Regional Dispersion Model (CRDM), which uses a national source-receptor matrix to estimate exposure associated with PM emissions.[24] Similarly, the Agency's analysis of the proposed Inter-state Air Quality Rule used the Regional Modeling System for Aerosols and Deposition (REMSAD), which also accounts for the long-range transport of particles.[25] In contrast, ISCST3 modeled exposure within a 20-kilometer radius of each emissions source for the 1999 risk assessment.[26] To the extent that PM is transported further than 20 km from each emissions source, the 1999 risk assessment may underestimate PM exposure. In addition, to estimate exposure in the 1999 risk assessment, EPA used block-group-level data from the 1990 Census. More recent studies use data from the 2000 Census.

More recent EPA benefits analyses also apply a different concentration-response function for PM mortality than that used for the 1999 risk assessment. In 1999, EPA used the concentration-response function published by Pope, et al. in 1995.[27] Since that time, health scientists have refined estimates of the concentration-response relationship, and EPA has updated its methodology for estimating benefits to reflect these more recent estimates. In its regulatory impact analysis of the non-hazardous boiler MACT standards, EPA used the Krewski, et al. re-analysis of the 1995 Pope study to estimate avoided premature mortality.[28] Since the relative risk estimated in the Krewski study (1.18) is nearly the same as that presented in Pope et al.(1.17), the Agency assumes that

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[24] U.S. EPA, *Regulatory Impact Analysis of The Final Industrial Boilers and Process Heaters NESHAP: Final Report*, February 2004.

[25] U.S. EPA, *Benefits of the Proposed Inter-State Air Quality Rule*, January 2004.

[26] Research Triangle Institute, *Human Health and Ecological Risk Assessment Support to The Development of Technical Standards for Emissions from Combustion Units Burning Hazardous Wastes: Background Document*, prepared for U.S. EPA, Office of Solid Waste, July 1999.

[27]Pope, C.A., III, M.J. Thun, M.M. Namboodiri, D.W. Dockery, J.S. Evans, F.E. Speizer, and C.W. Heath, Jr. 1995. Particulate air pollution as a predictor of mortality in a prospective study of U.S. adults. American Journal of Respiratory and Critical Care Medicine151:669-674, as cited in Research Triangle Institute, *op. cit*.

[28] Krewski D, Burnett RT, Goldbert MS, Hoover K, Siemiatycki J, Jerrett M, Abrahamowicz M, White WH. 2000. Reanalysis of the Harvard Six Cities Study and the American Cancer Society Study of Particulate Air Pollution and Mortality. Special Report to the Health Effects Institute, Cambridge MA, July 2000.

updating the 1999 risk assessment to reflect the results of the 2000 Krewski study would have minimal impact on the estimated benefits associated with the proposed HWC MACT replacement standards.

To assess benefits from reduced exposure to particulate matter in 1999, we first estimated the number of excess mortality and hospital admissions in the baseline and under various 1999 MACT standard scenarios. We then subtracted the number of cases post-MACT from the number of cases in the baseline to determine potential avoided deaths and hospital admissions. Hospital admissions are associated with respiratory illness and cardiovascular disease. For the current assessment we scaled the cases found in the 1999 *Assessment* to reflect current conditions and emission reductions achieved by the proposed HWC MACT replacement standards.

In addition to avoided illnesses and deaths, benefits of reduced PM emissions include valuation of work loss days and mild restricted activity days (MRAD). To assess benefits from reduced particulate matter exposure, we first estimated the number of excess mortality cases, cases of illnesses, restricted activity days, and work loss days in the baseline. We then estimate the number of cases under four MACT standards: Option 1 Floor, Option 2 Floor, Option 3 Floor, and Agency Preferred Approach. To determine potential benefits for each option, we then subtract the number of post-MACT cases from the number of baseline cases. We estimated benefits based on the dollar value associated with the following health conditions:

- respiratory illness,
- upper respiratory symptoms,
- lower respiratory symptoms,
- chronic bronchitis,
- acute bronchitis,
- cardiovascular disease,
- work loss days, and
- mild restricted activity days (MRAD).[29]

[29] Work loss days and mild restricted activity days do not necessarily affect a worker's income and do not generally require hospitalization. It does, however, result in lost economic productivity and consequently, a loss to society.

For avoided deaths, we assign monetary values in the same way as for avoided cancer cases, using a range of estimates for the statistical value of a life (see discussion above). For the avoided illnesses listed above, we estimate the avoided costs of hospital admissions for each of the health effects associated with exposure to particulate matter. To value the morbidity risk reductions, we multiply the expected number of annual reductions in hospital admissions for each ailment by the cost of illness for that condition, as shown in Exhibit 6-2. The estimated cost of each illness includes the hospital charge, the costs of associated physician care, and the opportunity cost of time spent in the hospital.[30] Since these estimates do not include post-hospital costs or pain and suffering of the afflicted individuals, the cost of illness estimates may understate benefits.

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[30] These estimates come from the following source: U.S. Environmental Protection Agency, *The Benefits and Costs of the Clean Air Act, 1970 to 1990*, October 1997, I11-I12. Estimates for COPD and physician charges for the remaining four illnesses come from Abt Associates, Incorporated, *The Medical Costs of Five Illnesses Related to Exposure to Pollutants,* Prepared for U.S. EPA, Office of Pollution Prevention and Toxics, Washington, DC, 1992, as cited in U.S. EPA, *Assessment of the Potential Costs, Benefits, and Other Impacts of the Hazardous Waste Combustion MACT Standards: Final Rule*, Office of Solid Waste, July 1999. Hospital charge estimates for the remaining illnesses are from A. Elixhauser, R.M. Andrews, and S. Fox, Agency for Health Care Policy and Research (AHCPR), Center for General Health Services Intramural Research, U.S. Department of Health and Human Services, *Clinical Classifications for Health Policy Research: Discharge Statistics by Principal Diagnosis and Procedure,* 1993, as cited in U.S. EPA, *Assessment of the Potential Costs, Benefits, and Other Impacts of the Hazardous Waste Combustion MACT Standards: Final Rule*, Office of Solid Waste, July 1999; Pope, C.A., III, D.W. Dockery, J.D. Spengler, and M.E. Raizenne. 1991. Respiratory Health and PM10 pollution: a Daily Time Series Analysis. American Review of Respiratory Diseases. 144: 668-674, as cited in U.S. EPA, *Draft Regulatory Impact Analysis: Control of Emission from Nonroad Diesel Engines*, Assessment and Standards Division, April 2003; Schwartz J.,and Nease L.M., 2000. Fine Particles are more strongly associated than coarse particles with acute respiratory health effects in schoolchildren. Epidemiology. 11L 6-10, as cited in U.S. EPA, *Draft Regulatory Impact Analysis: Control of Emission from Nonroad Diesel Engines,* Assessment and Standards Division, April 2003; Schwartz J., Dockery, D.W., Nease, L.M., Wypij, D., Ware, J.H., Spengler, J.D., Koutrakis, P.,Speizer, F.E., and Ferris, Jr., B.G. 1994. Acute Effects of Summer Air Pollution on Respiratory Symptom Reporting in Children. American Journal of Respiratory Critical Care Medicine. 150. 1234-1242, as cited in U.S. EPA, *Draft Regulatory Impact Analysis: Control of Emission from Nonroad Diesel Engines*, Assessment and Standards Division, April 2003; and Dockery, D.W., J. Cunningham, A.I. Damokosh, L.M. Neas, J.D. Spengler, P. Koutrakis, J.H. Ware, M. Raizenne, and F.R. Speizer. 1996. Health Effects of Acid Aerosols on North American Children-Respiratory Symptoms. Enviromental Health Perspectives. 104(5)" 500-505.

Exhibit 6-2

AVOIDED COST OF CASES ASSOCIATED WITH PM

Illness	Estimated Cost Per Incidence (2002 $)
Respiratory Illness[1]	$9,011
Upper respiratory symptoms[2]	$27
Lower respiratory symptoms[3]	$18
Chronic bronchitis[4]	$377,229
Acute bronchitis[5]	$55
Cardiovascular disease[1]	$15,018
Work loss days (cost per day)[1]	$112
Minor restricted activity days (cost per day)[1]	$39

Sources:
[1] U.S. Environmental Protection Agency, *The Benefits and Costs of the Clean Air Act, 1970 to 1990*, October 1997, I11-I12
[2] Pope, C.A., III, D.W. Dockery, J.D. Spengler, and M.E. Raizenne. 1991. Respiratory Health and PM10 pollution: a Daily Time Series Analysis. American Review of Respiratory Diseases. 144: 668-674, as cited in U.S. EPA, *Draft Regulatory Impact Analysis: Control of Emission from Nonroad Diesel Engines*, Assessment and Standards Division, April 2003.
[3] Average of Schwartz J.,and Nease L.M., 2000. Fine Particles are more strongly associated than coarse particles with acute respiratory health effects in schoolchildren. Epidemiology. 11L 6-10, as cited in U.S. EPA, *Draft Regulatory Impact Analysis: Control of Emission from Nonroad Diesel Engines*, Assessment and Standards Division, April 2003; and Schwartz J., Dockery, D.W., Nease, L.M., Wypij, D., Ware, J.H., Spengler, J.D., Koutrakis, P.,Speizer, F.E., and Ferris, Jr., B.G. 1994. Acute Effects of Summer Air Pollution on Respiratory Symptom Reporting in Children. American Journal of Respiratory Critical Care Medicine. 150. 1234-1242, as cited in U.S. EPA, *Draft Regulatory Impact Analysis: Control of Emission from Nonroad Diesel Engines*, Assessment and Standards Division, April 2003.
[4] U.S. EPA, *Benefits of the Proposed Inter-State Air Quality Rule*, January 2004.
[5] Neumann, J.E., M.T. Dickie, and R.E. Unsworth. 1994. Industrial Economics, Incorporated. Memorandum to Jim DeMocker, U.S. EPA, Office of Air and Radiation. Linkage Between Health Effects Estimation and Morbidity Valuation in the Section 812 Analysis -- Draft Valuation Document. March 31.
Note: Cardiovascular disease is assumed to be Ischemic heart disease.

Benefits from Reduced Exposure to Lead

The primary effect from chronic exposure to lead is to the central nervous system. Children are particularly sensitive to the effects of lead and excess exposure can affect a child's nervous system and cognitive development. The proposed HWC MACT replacement standards will reduce lead emissions by approximately five to seven tons per year for the Floor and Agency Preferred Approach options, or less than 0.01 pounds per person.[31] The 1999 standards were expected to reduce lead emissions by 89 tons per year, or 0.17 pounds per person, and were expected to reduce cumulative lead exposures for seven children age 0-5 to less than 10 μg/dL. The benefits associated with the replacement standards are expected to be more modest per year, reducing the cumulative lead exposures for fewer than seven children age 0-5, to less than 10 μg/dL annually.

The *Benefits and Costs of the Clean Air Act, 1970 to 1990* monetizes benefits of reduced lead emissions by associating high blood lead levels with reduction in IQ.[32] The analysis estimates annual benefits of about $42 million associated with reductions ranging from 5,000 to 13,000 tons of lead, depending on the year.[33] The reduction of lead emissions and increase in IQ does not display a linear relationship and cannot be transferred to this analysis so we do not attempt to monetize them.

Benefits from Reduced Exposure to Mercury

Reduced mercury emissions under the proposed replacement standards may generate a range of human health benefits.[34] A reduction in mercury emissions is likely to reduce the deposition of mercury in lakes, rivers, and streams, which will subsequently reduce bioaccumulation of methylmercury in fish. Since consumption of fish containing methylmercury may cause adverse health effects, reductions in the bioaccumulation of methylmercury in fish could lead to human health benefits.

When humans consume fish containing methylmercury, the ingested methylmercury is absorbed into the blood and distributed to tissue throughout the body. In pregnant women, methylmercury can be passed on to the developing fetus, leading to a number of neurological

[31] Based on the population estimated in the 1999 *Assessment*.

[32] U.S. EPA, *The Benefits and Costs of the Clean Air Act, 1970 to 1990*, October 1997.

[33] Benefits estimate was converted to 2002 dollars using the Consumer Price Index for all goods. WTP estimates are converted using the Consumer Price Index for all goods, while cost of illness estimates are converted using the Consumer Price Index for medical expenditures only.

[34] The benefits discussion that follows in the rest of this paragraph is adapted from EPA, *Regulatory Impact Analysis of the Final Industrial Boilers and Process Heaters NESHAP: Final Report*, February 2004. Additional information related to the health effects associated with mercury are provided in chapter 9 of this report.

disorders in children. These disorders can lead to learning disabilities and developmental problems, which may lead to later adverse economic consequences. The effects of prenatal exposure can occur at doses that do not affect the mother. In addition, children who consume fish containing methylmercury may develop neurological disorders, which may lead to other adverse economic effects. A more detailed description of the benefits associated with reduced mercury exposure is presented in EPA's regulatory impact analysis of the non-hazardous boiler MACT standards.[35]

Since the numerical relationship between mercury exposure and the health effects described above is highly uncertain, we do not quantify the benefits associated with reduced mercury emissions. Instead, we present a qualitative discussions of the benefits that might result from the proposed HWC MACT replacement standards for mercury.

Benefits from Reduced Exposure to Chlorine

This analysis does not quantify the benefits associated with reductions in chlorine emissions. The replacement standards are expected to reduce total chlorine emissions, a combination of hydrogen chloride (HCl) and chlorine gas (Cl_2) emissions, by approximately 1,426 to 4,806 tons per year for the Floor options and 2,490 tons per year for the Agency Preferred Approach (Exhibit 6-3). Hydrogen chloride is corrosive to the eyes, skin, and mucous membranes. Acute inhalation can cause eye, nose, and respiratory tract irritation and inflamation, and pulmonary edema. Chronic occupational inhalation has been reported to cause gastritis, bronchitis, and dermatitis in workers. Long term exposure can also cause dental discoloration and erosion. No information is available on the reproductive or developmental effects in humans. Chlorine gas inhalation can cause bronchitis, asthma and swelling of the lungs, headaches, heart disease, and meningitis. Acute exposure causes more severe respiratory and lung effects, and can result in fatalities. No information is available on the reproductive or developmental effects in humans. The proposed HWC MACT replacement standards are expected to reduce chlorine exposure for people in close proximity to hazardous waste combustion facilities, and are therefore likely to reduce the risk of all of these health effect among those populations. However, without detailed exposure modeling it is not possible to quantify the impact of the proposed HWC MACT replacement standards.

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[35] EPA, *Regulatory Impact Analysis of the Final Industrial Boilers and Process Heaters NESHAP: Final Report*, February 2004.

Human Health Benefit Results

This section discusses quantified human health benefits from risk reductions related to PM emissions reductions for each of the Floor options and the Agency Preferred Approach. Cancer risk reductions associated with dioxin emissions reductions are also discussed. In addition, benefits from reduced exposure to lead and mercury are discussed and compared to the 1999 standards benefits estimates. Finally, we are not able to quantify benefits to reduced exposure to chlorine but we discuss potential effects of hydrogen chloride and chlorine gas.

In general, the 1999 standards resulted in greater incremental emissions reductions than are expected under the proposed HWC MACT replacement standards (Exhibit 6-3). This is reasonable given that the proposed HWC MACT replacement standards address only emissions reductions not already captured by the 2002 interim standards. One notable exception is that Option 3 Floor is associated with a greater PM emissions reduction than the options considered for the 1999 standards. Among the proposed HWC MACT replacement standards options Option 3 Floor is expected to result in the most human health benefits. The Agency Preferred Approach is expected to result in more human health benefits than Option 1 Floor and Option 2 Floor.

Exhibit 6-3

ANNUAL EMISSIONS REDUCTIONS FOR THE PROPOSED HWC MACT REPLACEMENT STANDARDS

Standard	Particulate Matter (tons/yr)[a]	Mercury (tons/yr)	SVM/LVM (tons/yr)	Dioxins/Furans (grams/yr)	Chlorine (tons/yr)
Agency Preferred Approach	*2,215 (9.7)*	*0.9*	*16.4*	*4.7*	*2,638*
Option 1 Floor	1,829 (4.7)	0.9	15.8	0.4	1,570
Option 2 Floor	1,829 (4.7)	1.3	16.7	0.4	3,106
Option 3 Floor	3,254 (15.5)	1.3	20.4	0.4	4,955
1999 Standard	*2,449 (6.2)*	*3.9*	*97.1*	*28.7*	*5,132*

Notes
a. Values in parentheses following the PM emissions reductions estimates represent emissions reductions of non-enumerated metals (i.e., antimony, cobalt, nickel, selenium, and manganese) attributable to the PM replacement standards.

A summary of the quantified benefits for the Agency Preferred Approach are provided in Exhibit 6-4, and the summary of quantified benefits of the Floor options are presented in Exhibit 6-5. Below, we describe the results in more detail.

Benefits from Cancer Risk Reductions

Dioxin - Less than 0.36 cancer cases per year are expected to be avoided due to the proposed HWC MACT replacement standards. Based on the 1999 *Assessment* the majority of the cancer risk reductions are linked to consumption of dioxin-contaminated agricultural products exported beyond the boundaries of the study area (e.g., within 20 km). Less than one-third of the cancer risk reductions occurred in local populations living near combustion facilities. Cancer risks for local populations were attributed primarily to reductions in arsenic and chromium emissions; these pollutants accounted for almost 85 percent of total local cancer incidence in the baseline.

In 1999, across all receptor populations, individual cancer risks were greatest for subsistence farmers, individuals who obtain the majority of their dietary intake of all agricultural commodities from home-production.[36] Dioxin and arsenic were the primary pollutants that drive the cancer risks for this sensitive receptor population. Lack of population data prevented the quantification of benefits for this hypothetical sub-population, but the reduction in risk from baseline to implementation of the 1999 standards was characterized. Subsistence farmers exposed to the highest individual risks faced getting cancer with a probability of five in 100,000.[37] With the exception of one particular scenario, the cancer risk for all subsistence farmers was reduced to below levels of concern after implementation of the 1999 standards.[38] The 1999 *Assessment* found that in addition to the cancer risk reductions for the overall population, the 1999 standards would result in lower cancer risks for the children of especially sensitive sub-populations. Children of subsistence farmers, who potentially face the greatest individual risk of any receptor population, were expected to experience a reduction in individual cancer risk by a factor as high as 0.005. Risk reductions may be associated with the proposed HWC MACT replacement standards, particularly near facilities with boilers and industrial furnaces that are not subject to regulation under the 2002 interim standards.

Benefits from Non-Cancer Risk Reductions

Most of the human health benefits from the proposed HWC MACT replacement standards come from reductions in particulate matter. Some additional benefits which are not quantified in this analysis, may come from reductions in exposure to lead, mercury, chlorine, and dioxin for

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[36] The following pathways pertain to this subsistence receptor: ingestion of home-produced beef, pork, chicken, eggs, milk, root vegetables, exposed fruit, exposed vegetables, and fish caught on farm ponds.

[37] The hypothetical scenario with the greatest individual cancer risk is that for children (ages 0-5 and 6-11) of subsistence farmers resulting from dioxin associated with commercial incinerator emissions.

[38] Baseline cancer risk for subsistence farmers ages 0-5 and 6-11 associated with cement kiln emissions was 2E-05; it remained 2E-05 following the implementation of the 1999 standards. It is important to emphasize that because of the absence of subsistence farmer population estimates, these hypothetical scenarios represent only the upper bound, worst case risks possible. No conclusions can be made as to the incidence rates associated with these hypothetical worst case individual risks.

people living near combustion facilities.[39] Total annual health benefits are valued at about $4.12 million under the Option 1 Floor and Option 2 Floor, $4.16 million under the Agency Preferred Approach, and $8.08 million for Option 3 Floor.

Particulate Matter. The proposed HWC MACT replacement standards are expected to avoid less than one premature death for each of the regulatory options, 54 illnesses annually for Option 1 Floor and Option 2 Floor and Agency Preferred Approach, and 105 illnesses annually for Option 3 Floor; all illnesses are associated with exposure to PM. These and other human health benefits related to reduced PM exposure are valued at $2.68 million to $5.64 million per year under the Agency Preferred Approach. Benefits from reduced exposure to PM come primarily from liquid boilers. Reductions in the number of respiratory diseases account for over half of the morbidity benefits. While separate results are not available for children, it is safe to assume that many of the respiratory health benefits will be experienced by children, who are thought to be especially vulnerable to the effects of PM exposure.[40]

Mercury. Mercury emitted from hazardous waste burning incinerators, kilns, boilers, and other natural and man-made sources is carried by winds through the air and eventually is deposited to water and land. Recent estimates (which are highly uncertain) of annual total global mercury emissions from all sources (natural and anthropogenic) are about 5,000 to 5,500 tons per year (tpy). Of this total, about 1,000 tpy are estimated to be natural emissions and about 2,000 tpy are estimated to be contributions through the natural global cycle of re-emissions of mercury associated with past anthropogenic activity. Current anthropogenic emissions account for the remaining 2,000 tpy. Point sources such as fuel combustion; waste incineration; industrial processes; and metal ore roasting, refining, and processing are the largest point source categories on a world-wide basis. Given the global estimates noted above, U.S. anthropogenic mercury emissions are estimated to account for roughly 3 percent of the global total, and U.S. hazardous waste burning incinerators, kilns, and boilers are estimated to account for about 0.0045 percent of total global emissions.

Mercury exists in three forms: elemental mercury, inorganic mercury compounds (primarily mercuric chloride), and organic mercury compounds (primarily methylmercury). Mercury is usually released in an elemental form and later converted into methylmercury by bacteria. Methylmercury may be more toxic to humans than other forms of mercury, in part because it is more easily absorbed in the body[41]. If the deposition is directly to a water body, then the processes of aqueous fate, transport, and transformation begin. If deposition is to land, then terrestrial fate and transport processes occur first and then aqueous fate and transport processes occur once the mercury has cycled into a water body. In both cases, mercury may be returned to the atmosphere through

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[39] Other pollutants were found to pose negligible individual risks and so are not included in the results.

[40] U.S. EPA, *Environmental Health Threats to Children*, EPA 175-F-96-001, September 1996, page 4.

[41] *Regulatory Impact Analysis of the Final Industrial Boilers and Process Heaters NESHAP: Final Report*, February 2004.

resuspension. In water, mercury is transformed to methylmercury through biological processes and for exposures affected by this rulemaking. Methylmercury is considered to be the form of greatest concern. Once mercury has been transformed into methylmercury, it can be ingested by the lower trophic level organisms where it can bioaccumulate in fish tissue (i.e., concentrations of mercury remain in the fish's system for a long period of time and accumulates in the fish tissue as predatory fish consume other species in the food chain). Fish and wildlife at the top of the food chain can, therefore, have mercury concentrations that are higher than the lower species, and they can have concentrations of mercury that are higher than the concentration found in the water body itself. In addition, when humans consume fish containing methylmercury, the ingested methymercury is almost completely absorbed into the blood and distributed to all tissues (including the brain); it also readily passes through the placenta to the fetus and fetal brain[42].

Based on the findings of the National Research Council, EPA has concluded that benefits of Hg reductions would be most apparent at the human consumption stage, as consumption of fish is the major source of exposure to methylmercury. At lower levels, documented Hg exposure effects may include more subtle, yet potentially important, neurodevelopmental effects. Some subpopulations in the U.S., such as: Native Americans, Southeast Asian Americans, and lower income subsistence fishers, may rely on fish as a primary source of nutrition and/or for cultural practices. Therefore, they consume larger amounts of fish than the general population and may be at a greater risk to the adverse health effects from Hg due to increased exposure. In pregnant women, methylmercury can be passed on to the developing fetus, and at sufficient exposure may lead to a number of neurological disorders in children. Thus, children who are exposed to low concentrations of methylmercury prenatally may be at increased risk of poor performance on neurobehavioral tests, such as those measuring attention, fine motor function, language skills, visual-spatial abilities (like drawing), and verbal memory. The effects from prenatal exposure can occur even at doses that do not result in effects in the mother. Mercury may also affect young children who consume fish containing mercury. Consumption by children may lead to neurological disorders and developmental problems, which may lead to later economic consequences.

In response to potential risks of mercury-containing fish consumption, EPA and FDA have issued fish consumption advisories which provide recommended limits on consumption of certain fish species for different populations. EPA and FDA have developed a new joint advisory that was released in March 2004. This new FDA-EPA fish advisory recommends that women and young children reduce the risks of Hg consumption in their diet by moderating their fish consumption, diversifying the types of fish they consume, and by checking any local advisories that may exist for local rivers and streams. This collaborative FDA-EPA effort will greatly assist in educating the most susceptible populations. Additionally, the reductions of Hg from this regulation may potentially lead to fewer fish consumption advisories (both from federal or state agencies), which will benefit the fishing community. Currently 44 states have issued fish consumption advisories for

[42] *Regulatory Impact Analysis of the Final Industrial Boilers and Process Heaters NESHAP: Final Report,* February 2004.

non-commercial fish for some or all of their waters due to contamination of mercury. The scope of FCA issued by states varies considerably, with some warnings applying to all water bodies in a state and others applying only to individual lakes and streams. Note that the absence of a state advisory does not necessarily indicate that there is no risk of exposure to unsafe levels of mercury in recreationally caught fish. Likewise, the presence of a state advisory does not indicate that there is a risk of exposure to unsafe levels of mercury in recreationally caught fish, unless people consume these fish at levels greater than those recommended by the fish advisory.

Reductions in methylmercury concentrations in fish should reduce exposure, subsequently reducing the risks of mercury-related health effects in the general population, to children, and to certain subpopulations. Fish consumption advisories (FCA) issued by the States may also help to reduce exposures to potential harmful levels of methylmercury in fish. To the extent that reductions in mercury emissions reduces the probability that a water body will have a FCA issued, there are a number of benefits that will result from fewer advisories, including increased fish consumption, increased fishing choices for recreational fishers, increased producer and consumer surplus for the commercial fish market, and increased welfare for subsistence fishing populations.

There is a great deal of variability among individuals in fish consumption rates; however, critical elements in estimating methylmercury exposure and risk from fish consumption include the species of fish consumed, the concentrations of methylmercury in the fish, the quantity of fish consumed, and how frequently the fish is consumed. The typical U.S. consumer eating a wide variety of fish from restaurants and grocery stores is not in danger of consuming harmful levels of methylmercury from fish and is not advised to limit fish consumption. Those who regularly and frequently consume large amounts of fish, either marine or freshwater, are more exposed. Because the developing fetus may be the most sensitive to the effects from methylmercury, women of child-bearing age are regarded as the population of greatest interest. The EPA, Food and Drug Administration, and many States have issued fish consumption advisories to inform this population of protective consumption levels.

The EPA's 1997 Mercury Study RTC supports a plausible link between anthropogenic releases of Hg from industrial and combustion sources in the U.S. and methylmercury in fish. However, these fish methylmercury concentrations also result from existing background concentrations of Hg (which may consist of Hg from natural sources, as well as Hg which has been re-emitted from the oceans or soils) and deposition from the global reservoir (which includes Hg emitted by other countries). Given the current scientific understanding of the environmental fate and transport of this element, it is not possible to quantify how much of the methylmercury in locally-caught fish consumed by the U.S. population is contributed by U.S. emissions relative to other sources of Hg (such as natural sources and re-emissions from the global pool). As a result, the relationship between Hg emission reductions from Phase I and Phase II sources assessed in this rule, and methylmercury concentrations in fish cannot be calculated in a quantitative manner with confidence. In addition, there is uncertainty regarding over what time period these changes would occur.

Given the present understanding of the Hg cycle, the flux of Hg from the atmosphere to land or water at one location is comprised of contributions from: the natural global cycle; the cycle perturbed by human activities; regional sources; and local sources. Recent advances allow for a general understanding of the global Hg cycle and the impact of the anthropogenic sources. It is more difficult to make accurate generalizations of the fluxes on a regional or local scale due to the site-specific nature of emission and deposition processes. Similarly, it is difficult to quantify how the water deposition of Hg leads to an increase in fish tissue levels. This will vary based on the specific characteristics of the individual lake, stream, or ocean.

Lead. The proposed HWC MACT replacement standards will reduce lead emissions by approximately five to seven tons per year for the Floor and Agency Preferred Approach options. In comparison, the 1999 standards were expected to reduce lead emissions by 89 tons per year, and were expected to reduce cumulative lead exposures for seven children age 0-5 to less than 10 µg/dL. The benefits associated with the proposed HWC MACT replacement standards are therefore expected to be modest, reducing the cumulative lead exposures for less than seven children age 0-5 less than 10 µg/dL annually.[43] The proposed HWC MACT replacement standards will also result in reduced lead levels for children of sub-populations with especially high levels of exposure. Children of subsistence fishermen, commercial beef farmers, and commercial dairy farmers who face the greatest levels of cumulative lead exposure will also experience comparable reductions in overall exposure as a result of the MACT standards. The small number of cases identified in the 1999 *Assessment* suggests that these benefits may be modest.

NOTE: *This chapter does not provide quantified or monetary estimates of the benefits associated with reduced dioxin emissions. However, estimates of the benefits associated with reduced dioxin emissions under the revised proposal for the HWC MACT replacement standards are available in EPA, "Addendum to the Assessment of the Costs, Benefits, and Other Impacts of the Hazardous Waste Combustion MACT Standards: Proposed Rule," March 2004. This document is available in the docket.*

Human Health Benefits Summary

The measurable annual human health benefits associated with emission reductions from Option 1 Floor and Option 2 Floor of the HWC MACT replacement standards include less than one avoided premature death, reductions of 1.3 hospital admission (respiratory illness and cardiovascular

[43]The primary form of lead exposure to children is via ingestion of contaminated soil.

disease involve hospital admissions), ten cases of bronchitis, 42 cases of respiratory symptoms, and about 4,200 days of work loss or MRAD. For Option 3 Floor annual human health benefits include less than one avoided premature death, reductions of three hospital admission, 19 cases of bronchitis, 83 cases of respiratory symptoms, and about 8,200 days of work loss or MRAD. Additional ecological and human health benefits are possible but not quantified in this analysis due to lack of data. Exhibit 6-6 summarizes the quanitifiable human health benefits across combustion sources for the Agency Preferred Approach and Floor options 1 through 3. Overall, the majority of the human health benefits are due to reductions in liquid boiler emissions. This is primarily due to the fact that liquid boilers comprise the largest portion of the total number of hazardous waste combustion systems, roughly 40 percent.

Annual human health benefits associated with emission reductions from the Agency Preferred Approach include less than one avoided premature death, reductions of 1.3 hospital admission, ten cases of bronchitis, 43 cases of respiratory symptoms, and about 4,200 days of work loss or MRAD. The Agency Preferred Approach does have additional health benefits that are not quantified, including chlorine, dioxin, metals, etc. This analysis quantifies only the human health benefits associated with reduction in PM emissions. Thus, the quantified Agency Preferred Approach benefits do not differ greatly from Option 1 Floor and Option 2 Floor and are less than Option 3 Floor (Exhibits 6-4 and 6-5).

However, one of the most substantial differences between the HWC MACT Standards Floor options and the Agency Preferred Approach is the increased reduction in dioxin emissions under the Agency Preferred Approach; an eleven-fold increase in emissions reduced is expected under the Agency Preferred Approach when compared to the Option 1 Floor (see Exhibit 6-3). The primary concern associated with dioxin is increased cancer risk. In the 1999 *Assessment* cancer risk reductions linked to consumption of dioxin-contaminated agricultural products exported beyond 20 km of the facility accounted for the majority of the 0.36 cancer cases per year that were expected to be avoided due to the 1999 standards. The incremental reduction in dioxin emissions from the Agency Preferred Approach is expected to be about 16 percent of the reductions achieved under the 1999 standards.

For the past 12 years the Agency has been conducting a reassessment of the human health risks associated with dioxin and dioxin-like compounds. This reassessment[44] will soon be under review at the National Academy of Sciences (NAS), as specified by Congress in the Conference Report accompanying EPA's fiscal year 2003 appropriation (Title IV of Division K of the Conference Report for the Consolidated Appropriations Resolution of 2003). Evidence compiled from this draft reassessment indicates that the carcinogenic effects of dioxin/furans may be as much as six times as great as believed in 1985, reflecting an upper bound cancer risk slope factor of 1 x

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[44] U.S.EPA, *Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TCDD) and Related Compounds*, September 2000. Note: Toxicity risk factors presented in this document should not be considered EPA's official estimate of dioxin toxicity, but rather reflect EPA's ongoing effort to reevaluate dioxin toxicity.

10^6 [mg/kg/day]$^{-1}$ for some individuals. Agency scientists' more likely (central tendency) estimates (derived from the ED_{01} rather than the LED_{01}) result in slope factors and risk estimates that are within 2-3 times of the upper bound estimates (i.e., between 3 x 10^5 [mg/kg/day]$^{-1}$ and 5 x 10^5 [mg/kg/day]$^{-1}$) based on the available epidemiological and animal cancer data. Risks could be as low as zero for some individuals.

Reduced dioxin emissions may result in additional cancer risk reductions for the most sensitive sub-populations: subsistence fishermen and farmers, and their children. Because we do not have population data for the most sensitive sub-populations, we can only describe individual risk results for subsistence farmers and fishermen and cannot make statements concerning the total number of people that may experience health benefits associated with the Agency Preferred Approach. In 1999, across all receptor populations, individual cancer risks were greatest for subsistence farmers. These cancer risks were driven primarily by dioxin and arsenic. Subsistence farmers exposed to the highest individual risks faced getting cancer with a probability of five in 100,000.[45] With the exception of one particular scenario, the cancer risk for all subsistence farmers was reduced to below levels of concern after implementation of the 1999 standards, based on risk data available at the time. However the 1999 standards did not address boilers and industrial furnaces.[46] Children of subsistence farmers, who potentially face the greatest individual risk of any receptor population, were expected to experience a reduction in individual cancer risk by a factor as high as 0.005.

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[45] The hypothetical scenario with the greatest individual cancer risk is that for children (ages 0-5 and 6-11) of subsistence farmers resulting from dioxin associated with commercial incinerator emissions.

[46] Baseline cancer risk for subsistence farmers ages 0-5 and 6-11 associated with cement kiln emissions was 2E-05; it remained 2E-05 following the implementation of the 1999 standards. It is important to emphasize that because of the absence of subsistence farmer population estimates, these hypothetical scenarios represent only the upper bound, worst case risks possible. No conclusions can be made as to the incidence rates associated with these hypothetical worst case individual risks.

Exhibit 6-4

**HUMAN HEALTH BENEFITS SUMMARY:
BASELINE TO AGENCY PREFERRED APPROACH**

Type of Benefit	Reduction in Number of Cases per Year	Annual Undiscounted Value (2002$) (millions)
Human Health Benefits		
Premature deaths avoided[a]	0.3	$1.81 ($0.33 - $3.29)
Respiratory illness	0.9	$0.01
Cardiovascular disease	0.4	$0.01
Chronic bronchitis	5.7	$2.14
Acute bronchitis	4.3	$0
Lower respiratory symptoms	38.4	$0
Upper respiratory symptoms	4.5	$0
Work loss days	451.1	$0.05
Minor restricted activity days	3,757.8	$0.15
Restricted Activity Days	1,237.5	NA[b]
Total Annual Monetary Benefits		**$4.16 ($2.68 - $5.64)**

Notes:

a. Avoided mortality is expressed in millions of 1999 dollars. Range of avoided mortality benefits reflects VSL range of $1.0 million to $10.0 million, consistent with the range presented in U.S. EPA *Benefits of the Proposed Inter-State Air Quality Rule*, January 2004.
b. To avoid potential double counting with minor restricted activity days, benefits associated with restricted activity days are not monetized.

Exhibit 6-5

HUMAN HEALTH BENEFITS SUMMARY: BASELINE TO PROPOSED HWC MACT REPLACEMENT STANDARDS FLOOR OPTIONS

Option	Option 1 Floor		Option 2 Floor		Option 3 Floor	
Type of Benefit	**Reduction in Number of Cases per Year**	**Annual Undiscounted Value (2002$) (millions)**	**Reduction in Number of Cases per Year**	**Annual Undiscounted Value (2002$) (millions)**	**Reduction in Number of Cases per Year**	**Annual Undiscounted Value (2002$) (millions)**
Human Health Benefits						
Premature deaths avoided	0.3	$1.79 ($0.33 - $3.26)	0.3	$1.79 ($0.33 - $3.26)	0.6	$3.53 ($0.64 - $6.42)
Respiratory illness	0.9	$0.01	0.9	$0.01	1.7	$0.02
Cardiovascular disease	0.4	$0.01	0.4	$0.01	0.8	$0.01
Chronic bronchitis	5.6	$2.12	5.6	$2.12	11.0	$4.13
Acute bronchitis	4.3	$0	4.3	$0	8.4	$0
Lower respiratory symptoms	38.1	$0	38.1	$0	74.2	$0
Upper respiratory symptoms	4.4	$0	4.4	$0	8.6	$0
Work loss days	447.3	$0.05	447.3	$0.05	874.7	$0.10
Minor restricted activity days	3,726.1	$0.15	3,726.1	$0.15	7,287.2	$0.29
Restricted activity days	1,227.1	NA[b]	1,227.1	NA[b]	2,399.8	NA[b]
Total Annual Monetary Benefits		**$4.12 ($2.66 - $5.59)**		**$4.12 ($2.66 - $5.59)**		**$8.08 ($5.19 - $10.97)**

Notes:
a. Range of avoided mortality benefits reflects VSL range of $1.0 million to $10.0 million, consistent with VSL estimates presented in U.S. EPA *Benefits of the Proposed Inter-State Air Quality Rule*, January 2004.
b. To avoid potential double counting with minor restricted activity days, benefits associated with restricted activity days are not monetized.

Exhibit 6-6

BENEFITS SUMMARY: CASES AVOIDED BY SOURCE, BASELINE TO PROPOSED HWC MACT REPLACEMENT STANDARDS

	Agency Recommended Approach		Option 1 Floor		Option 2 Floor		Option 3 Floor	
Type of Benefit	**Reduction in Number of Cases per Year**	**Annual Undiscounted Value (2002$ millions)**	**Reduction in Number of Cases per Year**	**Annual Undiscounted Value (2002$ millions)**	**Reduction in Number of Cases per Year**	**Annual Undiscounted Value (2002$ millions)**	**Reduction in Number of Cases per Year**	**Annual Undiscounted Value (2002$ millions)**
LWAK/Human Health Benefits								
Premature deaths avoided	0.0	$0.00	0.0	$0.00	0.0	$0.00	0.0	$0.00
Respiratory illness	0.0	$0.00	0.0	$0.00	0.0	$0.00	0.0	$0.00
Cardiovascular disease	0.0	$0.00	0.0	$0.00	0.0	$0.00	0.0	$0.00
Chronic bronchitis	0.1	$0.03	0.1	$0.03	0.1	$0.03	0.1	$0.03
Acute bronchitis	0.1	$0.00	0.1	$0.00	0.1	$0.00	0.1	$0.00
Lower respiratory symptoms	0.5	$0.00	0.5	$0.00	0.5	$0.00	0.5	$0.00
Upper respiratory symptoms	0.1	$0.00	0.1	$0.00	0.1	$0.00	0.1	$0.00
Work loss days	4.2	$0.00	4.2	$0.00	4.2	$0.00	4.2	$0.00
Minor restricted activity	35.0	$0.00	35.0	$0.00	35.0	$0.00	35.0	$0.00
Subtotal		$0.03		$0.03		$0.03		$0.03
Cement Kilns/Human Health Benefits								
Premature deaths avoided	0.0	$0.00	0.0	$0.00	0.0	$0.00	0.0	$0.00
Respiratory illness	0.0	$0.00	0.0	$0.00	0.0	$0.00	0.0	$0.00
Cardiovascular disease	0.0	$0.00	0.0	$0.00	0.0	$0.00	0.0	$0.00
Chronic bronchitis	0.1	$0.03	0.1	$0.03	0.1	$0.03	0.1	$0.04
Acute bronchitis	0.1	$0.00	0.1	$0.00	0.1	$0.00	0.1	$0.00
Lower respiratory symptoms	0.6	$0.00	0.6	$0.00	0.6	$0.00	0.9	$0.00
Upper respiratory symptoms	0.1	$0.00	0.1	$0.00	0.1	$0.00	0.1	$0.00
Work loss days	4.1	$0.00	4.1	$0.00	4.1	$0.00	5.9	$0.00
Minor restricted activity	34.4	$0.00	34.4	$0.00	34.4	$0.00	48.9	$0.00

Exhibit 6-6

BENEFITS SUMMARY: CASES AVOIDED BY SOURCE, BASELINE TO PROPOSED HWC MACT REPLACEMENT STANDARDS

	Agency Recommended Approach		Option 1 Floor		Option 2 Floor		Option 3 Floor	
Type of Benefit	Reduction in Number of Cases per Year	Annual Undiscounted Value (2002$ millions)	Reduction in Number of Cases per Year	Annual Undiscounted Value (2002$ millions)	Reduction in Number of Cases per Year	Annual Undiscounted Value (2002$ millions)	Reduction in Number of Cases per Year	Annual Undiscounted Value (2002$ millions)
Subtotal		$0.03		$0.03		$0.03		$0.05
All Incinerators/Human Health Benefits								
Premature deaths avoided	0.0	$0.11	0.0	$0.11	0.0	$0.11	0.0	$0.20
Respiratory illness	0.0	$0.00	0.0	$0.00	0.0	$0.00	0.1	$0.00
Cardiovascular disease	0.0	$0.00	0.0	$0.00	0.0	$0.00	0.0	$0.00
Chronic bronchitis	0.3	$0.12	0.3	$0.12	0.3	$0.12	0.6	$0.23
Acute bronchitis	0.3	$0.00	0.3	$0.00	0.3	$0.00	0.5	$0.00
Lower respiratory symptoms	2.4	$0.00	2.4	$0.00	2.4	$0.00	4.4	$0.00
Upper respiratory symptoms	0.3	$0.00	0.3	$0.00	0.3	$0.00	0.5	$0.00
Work loss days	27.5	$0.00	27.5	$0.00	27.5	$0.00	50.4	$0.01
Minor restricted activity	229.1	$0.01	229.1	$0.01	229.1	$0.01	419.9	$0.02
Subtotal		$0.25		$0.25		$0.25		$0.45

Exhibit 6-6

BENEFITS SUMMARY: CASES AVOIDED BY SOURCE, BASELINE TO PROPOSED HWC MACT REPLACEMENT STANDARDS

	Agency Recommended Approach		Option 1 Floor		Option 2 Floor		Option 3 Floor	
Type of Benefit	Reduction in Number of Cases per Year	Annual Undiscounted Value (2002$ millions)	Reduction in Number of Cases per Year	Annual Undiscounted Value (2002$ millions)	Reduction in Number of Cases per Year	Annual Undiscounted Value (2002$ millions)	Reduction in Number of Cases per Year	Annual Undiscounted Value (2002$ millions)
Coal Boilers/Human Health Benefits								
Premature deaths avoided	0.0	$0.02	0.0	$0.00	0.0	$0.00	0.0	$0.00
Respiratory illness	0.0	$0.00	0.0	$0.00	0.0	$0.00	0.0	$0.00
Cardiovascular disease	0.0	$0.00	0.0	$0.00	0.0	$0.00	0.0	$0.00
Chronic bronchitis	0.1	$0.02	0.0	$0.00	0.0	$0.00	0.0	$0.00
Acute bronchitis	0.0	$0.00	0.0	$0.00	0.0	$0.00	0.0	$0.00
Lower respiratory symptoms	0.4	$0.00	0.0	$0.00	0.0	$0.00	0.0	$0.00
Upper respiratory symptoms	0.0	$0.00	0.0	$0.00	0.0	$0.00	0.0	$0.00
Work loss days	4.2	$0.00	0.4	$0.00	0.4	$0.00	0.4	$0.00
Minor restricted activity	34.9	$0.00	3.2	$0.00	3.2	$0.00	3.2	$0.00
Subtotal		$0.04		$0.00		$0.00		$0.00
HCl Production Furnaces/ Human Health Benefits								
Premature deaths avoided	0.0	$0.00	0.0	$0.00	0.0	$0.00	0.0	$0.00
Respiratory illness	0.0	$0.00	0.0	$0.00	0.0	$0.00	0.0	$0.00
Cardiovascular disease	0.0	$0.00	0.0	$0.00	0.0	$0.00	0.0	$0.00
Chronic bronchitis	0.0	$0.00	0.0	$0.00	0.0	$0.00	0.0	$0.00
Acute bronchitis	0.0	$0.00	0.0	$0.00	0.0	$0.00	0.0	$0.00
Lower respiratory symptoms	0.0	$0.00	0.0	$0.00	0.0	$0.00	0.0	$0.00
Upper respiratory symptoms	0.0	$0.00	0.0	$0.00	0.0	$0.00	0.0	$0.00
Work loss days	0.0	$0.00	0.0	$0.00	0.0	$0.00	0.0	$0.00

Exhibit 6-6

BENEFITS SUMMARY: CASES AVOIDED BY SOURCE, BASELINE TO PROPOSED HWC MACT REPLACEMENT STANDARDS

	Agency Recommended Approach		Option 1 Floor		Option 2 Floor		Option 3 Floor	
Type of Benefit	**Reduction in Number of Cases per Year**	**Annual Undiscounted Value (2002$ millions)**	**Reduction in Number of Cases per Year**	**Annual Undiscounted Value (2002$ millions)**	**Reduction in Number of Cases per Year**	**Annual Undiscounted Value (2002$ millions)**	**Reduction in Number of Cases per Year**	**Annual Undiscounted Value (2002$ millions)**
Minor restricted activity	0.0	$0.00	0.0	$0.00	0.0	$0.00	0.0	$0.00
Subtotal		$0.00		$0.00		$0.00		$0.00
Liquid Boilers/Human Health Benefits								
Premature deaths avoided	0.3	$1.68	0.3	$1.68	0.3	$1.68	0.6	$3.33
Respiratory illness	0.8	$0.01	0.8	$0.01	0.8	$0.01	1.6	$0.01
Cardiovascular disease	0.4	$0.01	0.4	$0.01	0.4	$0.01	0.7	$0.01
Chronic bronchitis	5.1	$1.94	5.1	$1.94	5.1	$1.94	10.2	$3.83
Acute bronchitis	3.9	$0.00	3.9	$0.00	3.9	$0.00	7.7	$0.00
Lower respiratory symptoms	34.5	$0.00	34.5	$0.00	34.5	$0.00	68.4	$0.00
Upper respiratory symptoms	4.0	$0.00	4.0	$0.00	4.0	$0.00	7.9	$0.00
Work loss days	411.1	$0.05	411.1	$0.05	411.1	$0.05	813.9	$0.09
Minor restricted activity	3,424.3	$0.13	3,424.3	$0.13	3,424.3	$0.13	6,780.1	$0.27
Subtotal		$3.81		$3.81		$3.81		$7.54
Total		**$4.16**		**$4.12**		**$4.12**		**$8.08**

VISIBILITY BENEFITS

Particulate matter emissions are a primary cause of reduced visibility. Changes in the level of ambient PM caused by the reduction in emissions from the proposed HWC MACT replacement standards will increase the level of visibility in some parts of the U.S. Visibility directly affects people's enjoyment of a variety of daily activities. Individuals value visibility both in the places they live and work, in the places they travel to for recreational purposes. For example, Chestnut and Row (1989) examined WTP for improved visibility in recreational settings.[47] In addition, Chestnut and Dennis (1997) used data representative of the Eastern United States from McClelland et al. (1991) to measure WTP in residential areas.[48,49]

We have incorporated these methods in *The Benefits and Costs of the Clean Air Act 1990 to 2010*. We can estimate the upper bound and lower bound benefits associated with PM emissions reductions with the proposed HWC MACT replacement standards using two different methodologies, each comparing reductions to those associated with the Clean Air Act.

The first approach assumes a linear relationship between PM reductions and visibility improvements. A national decrease of PM emissions of two percent (823,000 tons annually) is associated with annual visibility benefits of roughly $2.75 billion (in 2002 dollars).[50] Assuming a linear relationship, reduced PM associated with the proposed HWC MACT replacement standards could result in a visibility benefit from approximately $6.12 million for the Option 1 Floor and the Option 2 Floor, $7.41 million for the Agency Preferred Approach, and $10.89 million for Option 3 Floor, proportional to national reductions. This comparative approach of linear extrapolation produces similar results ($6.12 million to $10.89 million) when comparing benefits of emissions reductions of the *Draft Regulatory Impact Analysis: Control of Emission from Nonroad Diesel Engines*.[51] The *Draft Regulatory Impact Analysis: Control of Emission from Nonroad Diesel Engines* used a similar approach to the *The Benefits and Costs of the Clean Air Act 1990 to 2010*. This approach has several limitations. In *The Benefits and Costs of the Clean Air Act 1990 to 2010*

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[47] Chestnut, L. and R. Rowe. 1989. "Economic Valuation of Changes in Visibility: A State of the Science Assessment for NAPAP," as cited in National Acid Preparation Assessment Program, Methods for Valuing Acidic Deposition and Air Pollution Effects. NAPAP State of Science and State of Technology Report No. 27, Part B. December, as cited in Industrial Economics, Incorporated, "Initial Review of Potential Benefits Associated with Hazardous Waste Combustion MACT Standards," Memorandum, prepared for U.S. EPA, 30 April,.2002.

[48] Chestnut, L. and R. Dennis. 1997. "Economic Benefits of Improvements in Visibility: Acid Rain Provisions of the 1990 Clean Air Act Amendments" Journal of Air and Waste Management Association 47:395-402, as cited in Industrial Economics, Incorporated, "Initial Review of Potential Benefits Associated with Hazardous Waste Combustion MACT Standards," Memorandum, prepared for U.S. EPA, 30 April, 2002.

[49] McClelland, G. et al. 1991. Valuing Eastern Visibility: A field test of the Contingent Valuation Method. Prepared for Office of Policy, Planning and Evaluation, USEPA, June, as cited in Industrial Economics, Incorporated, "Initial Review of Potential Benefits Associated with Hazardous Waste Combustion MACT Standards," Memorandum, prepared for U.S. EPA, 30 April, 2002.

[50] U.S. EPA, *The Benefits and Costs of the Clean Air Act 1990 to 2010*, November 1999.

[51] U.S. EPA, *Draft Regulatory Impact Analysis: Control of Emission from Nonroad Diesel Engines*, Assessment and Standards Division, April 2003.

and *Draft Regulatory Impact Analysis: Control of Emission from Nonroad Diesel Engines* EPA valued recreational visibility (e.g., realized through visits to Class 1 areas, most of which are National Parks).[52] In this *Assessment* no quantified analysis of the proximity of facilities to Class I areas has been performed. Another limitation of this method is that it assumes that visibility improvements are related to direct PM emissions only. In both *The Benefits and Costs of the Clean Air Act 1990 to 2010* and *Draft Regulatory Impact Analysis: Control of Emission from Nonroad Diesel Engines* EPA valued both direct PM emissions and gaseous PM precursors. No reductions in gaseous precursors are quantified for the proposed HWC MACT replacement standards, thus, this method may overestimate visibility benefits and represents the upper bound of potential visibility benefits.

The second approach is to assume a linear relationship between health benefits and visibility benefits associated with reduction in PM emissions. In *The Benefits and Costs of the Clean Air Act 1990 to 2010* annual human health benefits of roughly \$93 to \$148 billion (2002 dollars) and visibility benefits of \$2 to \$3 billion are estimated for reductions in PM emissions.[53] In the *Draft Regulatory Impact Analysis: Control of Emission from Nonroad Diesel Engines* the Agency estimated human health benefits of \$61 to \$108 billion (2002 dollars) and visibility benefits of \$1 to \$2 billion associated with reductions in PM emissions.[54] Assuming a linear relationship between human health benefits and visibility benefits, the proposed HWC MACT replacement standards could result in a visibility benefit of approximately \$104,900 for the Option 1 Floor and Option 2 Floor, \$105,800 for the Agency Preferred Approach, and \$205,500 for Option 3 Floor. This approach also has several limitations as it still does not take into account Class I areas, or any reductions in PM precursors. This method represents the lower bound of visibility benefits.

ECOLOGICAL BENEFITS

This section provides a comparison of the ecological benefits derived in the 1999 *Assessment* and the potential benefits associated with the proposed HWC MACT replacement standards. Ecological benefits derived in the 1999 *Assessment* were based on a screening analysis for ecological risks that compared soil, surface water, and sediment concentrations with eco-toxicological criteria based on *de minimis* thresholds for ecological effects. Because these criteria represented conservative values, an exceedence of the eco-toxicological criteria only indicates the **potential** for adverse ecological effects and does not necessarily indicate ecological damages. For this reason, the benefits of avoiding adverse ecological impacts were discussed qualitatively.

[52] Although no quantified analysis of the proximity of facilities to Class 1 areas has been performed, facilities are distributed over a wide area including Gulf of Mexico Coast, Great Lakes, and the Mississippi which include numerous recreation areas. Also, the WTP of households for increases in residential visibility is higher than their WTP for recreational visibility. The EPA, in *The Benefits and Costs of the Clean Air Act 1990 to 2010*, estimated the WTP per household for residential visibility changes to be \$141, and \$65 to \$137 for recreational visibility changes in National Parks (depending on household and park location). Thus, visibility benefits are likely.

[53] U.S. EPA, *The Benefits and Costs of the Clean Air Act 1990 to 2010*, November 1999.

[54] U.S. EPA, *Draft Regulatory Impact Analysis: Control of Emission from Nonroad Diesel Engines*, Assessment and Standards Division, April 2003.

The basic approach for determining whether ecosystems and/or biota are potentially at risk consisted of five steps:

- First, the risk assessment identified susceptible ecological receptors. Because combustion facilities are located across the country, ecological receptors for the screening analysis were chosen to represent relatively common species and communities of wildlife.[55]

- Second, the risk assessment developed eco-toxicological criteria for receptors that represent acceptable pollutant concentrations (e.g., at these levels, there is a low potential for adverse ecological effects).[56]

- Third, the risk assessment estimated baseline and post-MACT pollutant concentrations in sediments, soils, and surface water in the study areas.

- Fourth, for each land area or water body modeled, the risk assessment compared the modeled media concentrations to ecologically protective levels to estimate eco-toxicological hazard quotients.

- Finally, to estimate the potential for adverse ecological effects in the study areas the risk assessment totaled the number of polar grid sectors (for terrestrial ecosystems) and water bodies (from aquatic ecosystems) with hazard quotients exceeding one.

To assess potential ecological benefits from the risk assessment results, the number of sectors or water bodies potentially at risk in the baseline with the number post-1999 standards were compared. The reduction in the number of sectors or water bodies potentially at risk indicated a potential for avoiding adverse ecological impacts. Monetary values were not assigned to these potential benefits because the surface area of land or water affected corresponding to the number of grid sectors or water bodies potentially at risk could not be calculated, and no clear link exists between an exceedance in the eco-toxicological criteria and a real benefit measure, such as increased fish populations, for which a benefits transfer approach could assign monetary values.

Ecological Benefit Results

Ecological benefits were assessed in the 1999 *Assessment* based on reductions of approximately 100 tons per year in dioxin/furans and selected metals. Lead was the only pollutant of concern for aquatic ecosystems. Mercury appeared to be of greatest concern for terrestrial ecosystems. Dioxin and lead emission reductions also provided some potential benefits for terrestrial ecosystems. Under the 1999 standards, the eco-toxicological hazard quotient was reduced to below the level of concern for 38 square kilometers of water surface area. For terrestrial ecosystems, the

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[55] Threatened and endangered species and/or habitats were not included in the analysis.

[56] A description of the eco-toxicological criteria developed can be found in "Description of the SERA Methodology," Memorandum Prepared by Research Triangle Institute, Prepared for the U.S. EPA, 20 February 1998.

land area that experienced reductions in ecological risk criteria below levels of concern ranged from 115 square kilometers to 147 square kilometers under the 1999 standards.[57] The proposed HWC MACT replacement standards will reduce dioxin/furans and selected metals from 17 tons annually for Option 1 Floor and Agency Preferred Approach, Option 2 Floor 18 tons annually, and 22 tons annually for Option 3 Floor. In general the proposed HWC MACT replacement standards will produce fewer incremental benefits than those estimated for the 1999 *Assessment* (and later, for the 2002 Interim standards). However, the 1999 *Assessment* did not estimate the ecological benefits of MACT standards for boilers and industrial furnaces. These systems were excluded from the universe in 1999 but are part of the universe addressed by the proposed HWC MACT repayment standards. As a result, while the total ecological benefits of the proposed rule are likely to be modest, areas near facilities with boilers may enjoy more significant ecological benefits under the proposed HWC MACT replacement standards than areas near facilities that have already complied with the 2002 Interim standards.

It is important to note that these reductions of ecological risk criteria below levels of concern only indicate the potential for an ecological improvement. It is not clear that a MACT standard would necessarily provide ecological benefits to areas around combustion facilities. Also, because the screening-level nature of the ecological risk assessment did not allow us to predict the type or magnitude of benefits, we could not assign monetary values to these potential ecological benefits.

Forest Health and Aesthetics

Mercury, lead, and chlorides are among the HAPs that can cause damage to the health and visual appearance of plants.[58] While the total value of forest health is difficult to estimate, visible deterioration in the health of forests and plants can cause a measurable change in recreation behavior. Several studies that measure the change in outdoor recreation behavior according to forest

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[57] The low-end estimate assumed the same waterbodies or land areas are affected by different pollutants. That is, under the six square kilometers of land nearby incinerators that experienced ecological improvements associated with lead emission reductions are captured in the 87 square kilometers of land nearby incinerators associated with mercury reductions.

[58] Although the primary pollutants which are detrimental to vegetation aesthetics and growth are tropospheric ozone, sulfur dioxide, and hydrogen fluoride, three pollutants which are not regulated in the MACT standards, some literature exists on the relationship between metal deposition and vegetation health (Studies cited in U.S. EPA. *Mercury Study Report to Congress, Volume VI: An Ecological Assessment for Anthropogenic Mercury Emissions in the United States*. December 1997).

health are available to place a value on aesthetic degradation of forests.[59] Although these studies are available, additional research is needed to fully understand the effects of these HAPs on the forest ecosystem. Thus, these benefits are not quantified in this analysis.

Productivity to Agricultural Land

Emissions that are sufficient to cause structural and aesthetic damage to vegetation are likely to affect growth as well. Little research has been done on the effects of compounds such as chlorine, heavy metals (as air pollutants), and PM on agricultural productivity.[60] Even though the potential for visible damage and production decline from metals and other pollutants suggests the proposed HWC MACT replacement standards could increase agricultural productivity these changes cannot be quantified.

WASTE MINIMIZATION BENEFITS

As discussed in Chapter 5, all commercial combustion facilities that remain in operation will experience increased costs under the MACT standards. To protect their profits, combustion facilities will have an incentive to pass these increased costs on to their customers in the form of higher combustion prices. In 1999 we conducted a waste minimization analysis to inform the expected price change under the 1999 (and later the 2002 interim) standards. Based on the results of this analysis, we estimated that as much as 240,000 tons of waste might be reallocated to waste minimization alternatives in response to higher combustion prices.[61] Since the publication of the 1999 *Assessment*, however, approximately 100,000 tons of waste have already been reallocated. In addition, given the current pricing structure of the hazardous waste combustion market, the costs of

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[59] See, for example, Brown, T.C. et al. 1989, *Scenic Beauty and Recreation Value: Assessing the Relationship*, In J. Vining, ed., Social Science and Natural Resources Recreation Management, Westview Press, Boulder, Colorado, as cited in Industrial Economics, Incorporated, "Initial Review of Potential Benefits Associated with Hazardous Waste Combustion MACT Standards," Memorandum, prepared for U.S. EPA, 30 April, 2002; this work studies the relationship between forest characteristics and the value of recreational participation. For estimates of the WTP of visitors and residents to avoid forest damage, also see Peterson, D.G. et al. 1987, *Improving Accuracy and Reducing Cost of Environmental Benefit Assessments*. Draft Report to the US EPA, by Energy and Resource Consultants, Boulder, Colorado, as cited in Industrial Economics, Incorporated, "Initial Review of Potential Benefits Associated with Hazardous Waste Combustion MACT Standards," Memorandum, prepared for U.S. EPA, 30 April, 2002; Walsh et al. 1990, Estimating the public benefits of protecting forest quality, *Journal of Forest Management,* 30:175-189, as cited in Industrial Economics, Incorporated, "Initial Review of Potential Benefits Associated with Hazardous Waste Combustion MACT Standards," Memorandum, prepared for U.S. EPA, 30 April, 2002; and Homes et al. 1992, *Economic Valuation of Spruce-Fir Decline in the Southern Appalachian Mountains: A comparison of Value Elicitation Methods.* Presented at the *Forestry and the Environment: Economic Perspectives Conference,* March 9-1, 1992 Jasper, Alberta, Canada, as cited in Industrial Economics, Incorporated, "Initial Review of Potential Benefits Associated with Hazardous Waste Combustion MACT Standards," Memorandum, prepared for U.S. EPA, 30 April, 2002.

[60] MacKenzie, James J., and Mohamed T. El-Ashry, Air Pollution's Toll on Forests and Crops (New Haven, Yale University Press, 1989).

[61] U.S. Environmental Protection Agency, *Addendum to the Assessment of the Potential Costs, Benefits, and Other Impacts of the Hazardous Waste Combustion MACT Standards: Final Rule,* July 23, 1999.

waste minimization alternatives in the short term generally exceed the cost of combustion.[62] When the additional costs of compliance with the MACT standards are taken into account, waste minimization alternatives still tend to exceed the higher combustion costs. This inelasticity in the demand for combustion suggests that in the short term large reductions in waste quantities are not likely.

While, short-tern options for waste-minimization may be limited it is likely that over the longer term (e.g. as production systems are updated) companies will continue to seek alternatives to expensive waste-management (e.g., source reduction). To the extent that increases in combustion prices provide additional incentive to adopt more efficient processes, the proposed HWC MACT replacement standard may contribute to the longer term process based waste minimization efforts. However, we are not able to isolate and quantify the specific impact of the proposed HWC MACT replacement standards on source reduction decisions.

No waste minimization impacts are captured in the quantitative analysis of costs and benefits presented in this Assessment. A quantitative assessment of the benefits associated with waste minimization at the source may result in double-counting of some of the benefits described earlier in this chapter. For example, waste minimization may further reduce emissions of hazardous air pollutants and therefore have a positive effect on public health. Emissions reductions beyond those necessary for compliance with the replacement standards are also not addressed in this benefits assessment. In addition, waste minimization is likely to result in specific types of benefits not captured in this Assessment. For example, waste generators that engage in waste minimization will experience a reduction in their waste handling costs and could also reduce the risk related to waste spills and waste management. The cost of implementing waste minimization technology has not been assessed in this analysis. These costs are likely to at least partially offset corresponding benefits.

[62] In the long-term, waste minimization may take place as companies upgrade manufacturing processes. However, increased waste management costs are only one factor in these larger decisions. We therefore do not anticipate that the replacement standards would cause a significant change in the quantity of waste combusted.

Exhibit 6-7

BENEFITS SUMMARY: BASELINE TO PROPOSED HWC MACT REPLACEMENT STANDARDS (2002 Dollars in Millions)

Option	Agency Preferred Approach		Option 1 Floor		Option 2 Floor		Option 3 Floor	
Type of Benefit	**Reduction in Number of Cases per Year**	**Annual Undiscounted Value**	**Reduction in Number of Cases per Year**	**Annual Undiscounted Value**	**Reduction in Number of Cases per Year**	**Annual Undiscounted Value**	**Reduction in Number of Cases per Year**	**Annual Undiscounted Value**
Human Health Benefits								
Premature deaths avoided[a]	0.3	$1.81 ($0.33 -$3.29)	0.3	$1.79 ($0.33 -$3.26)	0.3	$1.79 ($0.33 -$3.26)	0.6	$3.53 ($0.64 -$6.42)
Respiratory illness	0.9	$0.01	0.9	$0.01	0.9	$0.01	1.7	$0.02
Cardiovascular disease	0.4	$0.01	0.4	$0.01	0.4	$0.01	0.8	$0.01
Chronic bronchitis	5.7	$2.14	5.6	$2.12	5.6	$2.12	11.0	$4.13
Acute bronchitis	4.3	$0	4.3	$0	4.3	$0	8.4	$0
Lower respiratory symptoms	38.4	$0	38.1	$0	38.1	$0	74.2	$0
Upper respiratory symptoms	4.5	$0	4.4	$0	4.4	$0	8.6	$0
Work loss days	451.1	$0.05	447.3	$0.05	447.3	$0.05	874.7	$0.10
Minor restricted activity days	3,757.8	$0.15	3,726.1	$0.15	3,726.1	$0.15	7,287.2	$0.29
Annual Monetary Health Benefits		**$4.16 ($2.68 -$5.64)**		**$4.12 ($2.66 -$5.59)**		**$4.12 ($2.66 -$5.59)**		**$8.08 ($5.19-$10.97)**
Visibility								
Annual Monetary Visibility Benefits		**$0.11 to $7.41**		**$0.10 to $6.12**		**$0.10 to $6.12**		**$0.21 to $10.89**
Total Annual Monetary Benefits		**$2.79 to $13.05**		**$2.76 to $11.71**		**$2.76 to $11.71**		**$5.40 to $21.86**

Notes:
a. Avoided mortality is expressed in millions of 1999 dollars. Range of avoided mortality benefits reflects VSL range of $1.0 million to $10.0 million, consistent with the range presented in U.S. EPA *Benefits of the Proposed Inter-State Air Quality Rule*, January 2004.

CONCLUSIONS

Overall, the Agency Preferred Approach is expected to result annually in approximately $4.16 million in human health benefits beyond the baseline. In addition, the proposed Agency Preferred Approach is expected to result in $105,800 to $7.41 million in visibility benefits beyond the baseline (see Exhibit 6-7 for a summary of the quantified annual monetary benefits of the proposed HWC MACT replacement standards). In particular, the Agency Preferred Approach is expected to result in:

- **Reductions in premature deaths.** Risk reductions associated with the Agency Preferred Approach is expected to result in less than one fewer premature deaths annually. Particulate matter accounts for most of the human health benefits.

- **Cancer risk reductions.** The Agency Preferred Approach is expected to avoid less than 0.36 cancer deaths annually when compared to the 1999 standards. The value of this avoided cancer case is not quantified in this *Assessment*.

- **Reductions in diseases associated with particulate matter exposure.** Hospital admissions for diseases associated with particulate matter are expected to be reduced by approximately 1.3 cases per year. Respiratory illnesses account for almost 70 percent of the hospital admissions. In addition, approximately 53 occurrences of acute respiratory conditions will be avoided annually due to the Agency Preferred Approach.

- **Reduced risk for mercury.** Reductions in methylmercury concentrations in fish should reduce exposure, subsequently reducing the risks of mercury-related health effects in the general population, to children, and to certain subpopulations. Fish consumption advisories (FCA) issued by the States may also help to reduce exposures to potential harmful levels of methylmercury in fish. To the extent that reductions in mercury emissions reduces the probability that a water body will have a FCA issued, there are a number of benefits that will result from fewer advisories, including increased fish consumption, increased fishing choices for recreational fishers, increased producer and consumer surplus for the commercial fish market, and increased welfare for subsistence fishing populations.

- **Reduced lead exposure in children.** The Agency Preferred Approach is expected to reduce lead exposure in children, including children of sub-populations with especially high levels of exposure (children of subsistence fishermen, commercial beef farmers, and commercial dairy farmers). However, the small number of cases identified in the 1999 *Assessment* suggests that these benefits may be modest.

- **Potential improvement in visibility.** An upper bound estimate of visibility benefits, assuming a linear relationship with WTP for improved visibility and particulate matter concentration visibility improvements associated with particulate matter, could result in benefits of $7.41 million annually for a 30 percent change in particulate matter concentration from the baseline. A lower bound estimate of visibility benefits, assuming a linear relationship between human health benefits and visibility benefits reductions in PM emissions, could result in $105,800 in visibility benefits.

- **Potential ecological improvements.** The Agency Preferred Approach is likely to result in some ecological benefits. In comparison with the 1999 standards the Agency Preferred Approach is likely to produce less ecological benefits than estimated in the 1999 *Assessment*. That is, less than 38 square kilometers of water, and 147 square kilometers of terrestrial areas may experience a decrease in potential risks to ecosystems.

- **Increased forest health and aesthetics**. Mercury, lead, and chlorides are among the HAPs that can cause damage to the health and visual appearance of plants. While the total value of forest health is difficult to estimate, visible deterioration in the health of forests and plants can cause a measurable change in recreation behavior. These benefits are not quantified in this analysis.

- **Increased productivity to agricultural land**. Emissions that are sufficient to cause structural and aesthetic damage to vegetation are likely to affect growth as well. The Agency Preferred Approach could increase agricultural productivity but are not quantified in this analysis.

- **Waste minimization benefits.** The Agency Preferred Approach is likely to produce a small reduction, if any, in short-term generation waste combusted because the demand for combustion is relatively inelastic. However, impacts fo this rule on long-term process decisions are unknown.

It is important to emphasize that the monetized portion of the benefits represent only a portion of the benefits associated with this rule. Specifically ecological benefits, chlorine, dioxin, mercury, lead, etc. health benefits are not quantified or monetized. In some locations these benefits may be significant. In addition, specific sub-populations near combustion facilities, including children and minority populations, may be disproportionately affected by environmental risks and may therefore enjoy more significant benefits. Chapter 7 provides a more detail discussion of the environmental justice and children's health implications of this proposed rule.